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THE USE OF PICTURES IN THE TEACHING OF GEOGRAPHY

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Pictures are considered as basic material in the teaching of geography, hence their use should be woven into the subject matter. In securing geographic understandings, pupils should be encouraged to read pictures as they read the printed page. The critical thing in developing this picture language is to offer something that can be of future use. The activities presented should be of such a nature that they become at once a part of the geographic structure.

Pictures used in geography study, to be of greatest value, should show the relation of cultural to natural items. The chief objective is to encourage the ability to read from pictures the significant cultural items and to explain in part their relation to the natural. An important cultural item in a picture of the average town in the wheat-growing section is the grain elevator. This is related to the level land, fertile soil, and growing season of the plains, the latter items to be read into the picture rather than out of it.

When pictures are wisely selected in terms of the understandings to be acquired, their use contributes much toward the mastery of geographic cores of thought. It is essential, however, that teachers recognize the limitations of pictures as a source of material and that they realize that not all understandings may be secured from them even though they be of high geographic quality. Pictures of monuments, cathedrals and government

buildings contain little of geographic value. A simple illustrative picture showing the operations in a flour mill is of the definition type. The study of such a picture does not develop the power of interpretation as does the study of a picture showing natural as well as cultural items. Since very often a picture tells but little, it is possible that several of the definition type may be necessary in giving a clear concept. Many pictures merely suggest or raise questions. For example, one of a pottery may not explain why the pottery is located at a given point even though clay pits are seen near by. Such pits may supply only coarse clay for the making of saggers rather than the material for molding a given grade of pottery. The outside appearance of a building may give no means for differentiating between a shoe and a cotton factory. Manufacturing is indicated, but there is no certainty as to the exact kind. Still a third type of picture, such as a picture of a cotton plantation, may definitely indicate the activity carried on.

It is necessary to bring geographic thinking to bear on what one is to get out of a picture. Naturally what one gets out of it geographically depends on what he brings to it. The first stage in geographic picture-reading ability is very largely a matter of recognition. This recognition of activities is compared to counting in arithmetic. At later stages pupils are able to read into pictures as well as out of them. By this time they have reached the stage that might well be compared to the adding stage in arithmetic. A fourth-grade pupil may recognize an agricultural activity as farming; later, when he is more versed in geographic knowledge, he will note that the men are engaged in a specific type of farming—grain, dairy or mixed farming. He will give reasons evidenced in the form of signs in the natural environment for these activities as well as signs of natural conditions not pictured. The pupil, at this stage, may also note the methods used and the degree of success with which the industry is carried on. The element of gradation enters into picture reading just as it does into other phases of study. Pupils need to be taught to read pictures one step at a time. Gradation in picture reading means widening the ability to read out of and into pictures. It involves more intensive use of pictures in strengthening the ability to think geographically. It is just as bad to force intensive picture study in advance of appropriate levels of study as it is to use over and over again the same pictures with no regard for gradation.

At the outset children should not be turned loose with pictures. Initiative and self-expression on their part should be encouraged through careful questioning. Since children do not know what to look for, the teacher should not say to them, "Study the picture," "Write a story about the picture," or "Tell about everything you see in the picture." Directions similar to these give the same bewildered feeling as is given to the adolescent when told before sufficient directions have been given to make a garment or to prepare a meal.

Let us consider the advantages of interpreting a picture of a Congo home when it is accompanied by the following exercise: "What signs of man's activities are seen in this picture? Why is this home so strikingly different from ours? Are there any suggestions as to the materials used? How is this house related to the trees? Why does it have a sloping roof?" An exercise such as this directs picture interpretation much more effectively than do the general directions previously given. It encourages picture reading and makes a much more lasting impression on pupils than does the repeating of passive statements of the following nature: "This house was made from trees of the forest. The roof is pointed. It is very steep. Etc."

Numbered pictures giving concepts of the two great river systems of Africa might well be given to each member of the class. As the pictures are interpreted, the numbers should be placed in the Nile or in the Congo column, which have previously been prepared. If the pupils have a true imagery of the place, they should be capable of recognizing ten Congo pictures.

It is well to assign each member of the class a picture for explanation. Each pupil interprets his picture in the light of what he has learned. The group as a whole may talk over the pictures, check certain ideas, note the "whys" and list them on the board. In asking questions of one another have the pupils make a list of new concepts. If they are slow in deciding on the type of activity and in tying it to the specific area, it might be necessary to say, "This picture of plantation agriculture might have been taken as far north of the equator as twenty degrees. Why is it possible to grow bananas in this section? How long is the growing season?" Appropriate questions concerning the planting and harvesting might also be asked. Finally, in tying the activity to latitude, a statement should be made concerning the fact that as one travels farther north the growing season becomes shorter.

Just as pictures make a definite contribution in motivating the introduction, so also do they make their contribution in reviewing work, when pupils enjoy acting as guides. They should be encouraged to arrange pictures in the order of their occurrence, to feel that it is a natural situation and that they are real travelers in a new place. They need to feel the water, picture the boats, and watch the people at work in the new land, since the pictures should give vividness to the words of the book.

Pictures contribute a large item to visual instruction when their recognition is used in summarizing geographical units. Certain things can be definitely tested through picture reading; therefore pupils should be held responsible for interpreting them. Certain questions which appear repeatedly are easily developed through the use of multiple-choice or true-false devices. The exercises which follow give suggestions to be used in interpretation of pictures:

1. Wild life in a tropical forest:
   a. What do you think of when you see this picture?
   b. Why do these animals suggest hunting?
   c. In what way is hunting related to the forest?
   d. How do you account for hunting in near-by open grass places?
2. Human carriers:
   a. Why are human carriers used instead of animals in the Congo forest?
   b. How do you account for the numerous insects?
   c. Why is there but little grass for beasts of burden?
   d. In what way does much shade affect the plants?
3. A banana plantation:
   a. What kind of plant is this?
   b. Why does it have a broad leaf?
   c. In what part of the world do bananas grow?
   d. Do they grow in all places having a twelve-month growing season?
   e. Why do foods of this kind grow where it is hot and wet?
4. The Congo:
   a. What significant activity is here carried on in its natural setting?
   b. Would you expect these people to fish frequently or only once in a while?
   c. Why do the fish spoil so quickly?
   d. How do these people fish?
   e. From what materials are these nets made?
5. A corn field:
   a. What crop is here being harvested?
   b. Name two natural conditions helping to explain this activity.
   c. About how much rainfall is necessary for the production of corn?
   d. Was this picture taken as far as fifty degrees north of the equator?
   e. Why is corn adapted to such a wide range of temperature?
   f. How long does it take corn to mature?

g. How long is the growing season?
h. What is the time or occurrence of the season?
i. Are there not other natural factors that help to explain the growing of corn?

6. A prosperous farming section in the corn belt:
   a. In what way do these well-painted buildings and good fences give an idea of fertile soil, level land, and prosperous conditions?
   b. Would you explain the presence of good roads in the same way?
   c. What kind of farming might be carried on here?
7. A Swiss scene in the Alps:
   a. What does this picture contribute to your knowledge of the ways of making a living among the mountains?
   b. Why do they make a living in this way?
   c. How does the hotel which is related to the slope and altitude contribute to the characteristics of Switzerland?
   d. In what way did the lake feature in helping to locate the site of the hotel?
   e. Why was the railway built along the depression leading to the mountain pass?
8. The tea harvest:
   a. What sign of work is suggested in this picture?
   b. In what part of the world was this picture taken?
   c. About how far from the equator is this place?
   d. Is tea always grown on the higher slopes?
9. A camel caravan:
   a. What does this figure suggest?
   b. Might this picture have been taken near Los Angeles? Buenos Aires? Cairo?
   c. What type of adjustment has here been made?
10. Here are pictures taken in India. Place a plus after the correct statements.
   a. No. 1 suggests little rainfall.
   b. No. 1 shows a cotton plantation.
   c. No. 2 suggests signs of a nine-month growing season.
   d. No. 3 indicates that arid conditions exist.
   e. No. 4 gives a suggestion of heavy rainfall.
   f. No. 2 pictures wheat fields.
11. Numbered pictures of industries are supplied. Pupils are to underline the name of the general kind of work shown:
   a. No. 1 shows signs of plowing, harrowing, harvesting.
   b. No. 2 shows signs of logging, farming, planting.
   c. No. 3 shows signs of seal fishing, trout fishing, cod fishing.
12. Miscellaneous group, to be checked with a plus or minus.
   a. A ten-month growing season.
   b. A place 30° from the equator.
   c. Arid conditions throughout the year.
   d. A place where roots go deep into the soil.

Pupils should be sent often to pictures, since growth in picture-reading ability is accomplished only through the repeated

performance of activities which in time become automatic. New types of pictures need to be introduced and "why" questions asked about the unfamiliar items shown on the landscape. Picture-reading tends to increase the outlook and to give greater ability in identifying significant geographical items. Frequent recognition of similar items soon leads one to read heavy rainfall into sloping-roofed houses, as well as other items related to heat and moisture. The banana picture, fitting into the above, should very early be a part of the landscape knowledge of children. A pupil may read a description of the growing bananas along the Congo, but unless he sees a picture he does not have real imagery.

Detailed work in picture study may be impossible, but simple exercises are far better than neglect or leaving to accidental discovery relationships suggested in pictures. Pictures making their contribution at the right time are an economical medium of conveying ideas and of correcting wrong impressions in the experiences of children. If properly motivated through the hunting for relationships, for further information pupils will want to turn to pictures for the answers to questions not given on the printed page.

BOG PLANTS RESEMBLE DESERT PLANTS BECAUSE OF NITROGEN LACK

Why plants growing in bogs, where there is always plenty of water, should have thick, tough, leathery leaves protected against evaporation, resembling desert plants in this respect has long been a puzzle to botanists. A German botanist, Dr. Kurt Mothes of the University of Halle a. Saale, believes he has found a possible key in the lack of nitrogen in bog water and soil, rather than anything to do with the water relationship itself.

He was struck by the fact that of all bog plants the sundews, which capture insects with the sticky fingers on their leaves and thereby get plenty of nitrogen, are the least desert-like in their appearance and structure. The same might be said of two groups of American insectivorous plants, the Venus flytrap and the pitcher plants.

To test the possibilities of his hypothesis, Dr. Mothes grew tobacco plants, which normally are anything but desert-like, in culture solutions containing plenty of other mineral nutrients but lacking in nitrogen. They responded by developing thick, tough, leathery leaves, with small stomata or "breathing pores" and other characteristic structures of desert plants.

The full technical discussion of Dr. Mothes' experiments is published in the German journal Biologisches Zentralblatt.—*Science Service.*

Rome endured as long as there were Romans. America will endure as long as we remain American in spirit and in thought.—DAVID STARR JORDON.

PSYCHOLOGICAL NOTIONS EXPRESSED IN MATHEMATICAL FORM[1]

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In spite of the fact that, popularly, psychology is reputed to deal with such categories as thinking, reasoning, imagining, memory and the like, it would be rather presumptuous of a psychologist to attempt to tell mathematicians how they think, reason about, imagine in, memorize and forget mathematics. Actually, modern psychology is little concerned with "how" save as we answer in terms of the products resulting from experimentally controllable conditions. It is only the results of such experiments that can be reduced to equations; hence to the possibility of adequate human manipulation and control. As a fellow teacher, in a department which in a few brief years time has come to draw quite heavily on this fundamental science, I come into contact daily with quite a number of students who have had more or less mathematics. Their ability to think or not to think, in mathematical terms—the latter perhaps predominating—is, accordingly, a matter of no small importance for the progress of one's own discipline, as well as being a matter of curiosity and interest from the viewpoint of the analysis of the psychological factors involved in the teaching, learning, remembering and utilizing—not to mention forgetting—of mathematical concepts.

Much—and much nonsense—has been written about the psychology of mathematics. Attempts, for example, have been made to analyze the thinking process on introspective grounds, but like most introspections, nothing turns up in the finished pie that was not in the original ingredients. Accordingly, light can come only from a discussion of the concrete method of learning particular mathematical things—as in attaining particular mathematical concepts—in the hope of being able to arrive at some generalizations later. We must turn mainly then to experiment for our data.

Experiment shows that learning is dependent upon insight; first, as to what the problem is; second, as to an appropriate method of attack, which to be effective should be motivated by a positive feeling of assurance that the end result will surely be

[1] Revision of a paper presented before the Ohio branch of the Mathematical Association of America, at Columbus, April 7, 1932.

forthcoming if only the steps are done in the right order—in other words, that a generality of attack may always be expected to yield positive results in terms of solutions. Experiment likewise shows that learning is permanent and the ordinary course of forgetting is delayed more or less permanently provided: First, that the learning takes place with an intent to remember; second, that the learning is thoroughly learned—to the point of "over-learning"; third, that the associations are fixed—to concrete realities as well as to abstract; fourth, if and when two or more senses—for example, the eye and the ear—are directly involved in the original perceptions; fifth, if two or more reactions—for example, speaking and writing—are involved in the fixing-in process; sixth, if the associations which are made do lead to a *generality* of attack or method, and finally, if the learning thus attained be frequently practiced during the long course of the forgetting curve. There are probably more but these will serve our purposes of the moment. Let us first give attention to the matter of insight.

It is shown by experiment that if one deals with rats, one must have a rat problem; that is a problem of rat-like insight and of a difficulty appropriate to the individual in question. In human subjects, it has been shown that insight into situations frequently comes suddenly. Oftentimes one can say "Yesterday, I had no insight. Today I have full insight." Pedagogically, this means simply and mainly "baby problems for babies; adult problems for adults."

Let us get at this by concrete examples. The problem of squaring a binomial is a case in point. For a student's mathematics really to function he must be able to "see" a binomial in such "binomial like" expressions as:

$$(a + b + c)$$

so that as the need arises he can apply "the rules" for binomial expansions to such "binomials" by "seeing" them in any of the following fashions:

$$(1) \quad (a + b) + c$$
$$(2) \quad (a + c) + b$$
$$(3) \quad (c + b) + a$$
$$(4) \quad (a + b + c) + 0$$

as well as other permutations of the above.

Thus, psychologically a problem exists not to be solved in agreement with the answer in the back of the book, but to draw out, to test out, and to educate the insight of the student. If he

has adequate insight, the task of getting the answer becomes a routine job, a mere routine procedure which of necessity we all must do on occasion, and one which accordingly should be made a matter of greatest possible efficiency by utilizing in the job all possible mechanical devices wherever these will assist. (The speaker believes fully in employing to the utmost, calculating machines, slide rules, tables, graphic log tables, nomographs and other devices wherever these will free minds from drudgery for thinking. Nothing destroys insight into and interest in parabolas so much as "rail fence" graphs for example. With calculating machines fifty plotting points can be found as readily as ten by hand.)

It accordingly follows that problems in "methods of attack" will give more insight into the nature of binomials, for example —and incidentally their expansion—than will any number of problems of: Expand $(a+b+c)^2$. The key directions for such a problem might read:—"Problem ———. Note the following expressions. (A list is here given.) Then write down as many different expressions of each of the above in the binomial form as you can think of. You should be able to write out at least eight for a; ten for $b \cdots$." You will note that this is *problem making* instead of *problem solving*.

The inductive approach, from easy to difficult, from known simple case to unknown more complicated generalizations, is likewise employed to cultivate insight and to facilitate the acquirement of *generalized* notions regarding binomials.

This is possibly best done by taking more and more complicated examples, such as the following:

$$A + B + C_1$$

$$A + \beta + C_1$$

$$\frac{A_0}{2} + \beta + \frac{C_1}{3}$$

$$\frac{A_0}{2} + \frac{1}{\beta} + \frac{C_1}{3}$$

requiring the student as a class exercise to write out all the possible binomials which they can think of in a period, which is interrupted by the teacher frequently with hints of new "types." In free association experiments, frequent new key-words are thus required in order to keep the mental machinery going. Ultimately these should all be squared as a class exercise. To

make your own problems wholesale and then successfully solve them is to achieve to the heights of insight.

The above may be combined profitably with the simple case of *generalizing* the squaring of binomials. A knowledge of the motivating power of well directed drill would lead one to believe that the generalizing of the squaring of a binomial should be practically fixed in three class exercises of 20 minutes each.

To do this we may use the kindergarten method of flash cards or the paired comparisons device, a machine for pairing all possible characters on one disk with all possible ones on a second disk before the series starts over.[2] The essential elements are that the student

(1) shall increase m-fold the number of associations formed in the twenty minutes of drill;

(2) that all verbalization—crutches—such as "the square of the first plus the algebraic product of two times the first by the second plus the square of the second" shall drop out of the picture as early as possible; or, preferably, shall never be introduced at all, in accordance with the principle

(3) that the method employed shall not be antagonistic to later associations. Specifically, considering that squaring polynomials is later to be learned, the above quoted rule is wrong; and,

$$(a + b)^2 \text{ is } (a^2 + b^2 + 2ab) \text{ and not } (a^2 + 2ab + b^2).$$

In fact, why learn the rule at all? The rule is just so much mental rubbish. It is as easy to learn the bare answer as to learn the rule. Squaring a binomial should be as much a matter of motor-verbal habit as is a hornpipe. Much of mathematics should be simply learned through such intensified drill, the obtaining of simple derivatives being cases in point.

(4) That a single incorrect association tending to form a habit shall not be allowed to form.

(5) That all students shall succeed from the outset.

This necessitates the teacher's giving the correct answer, or by flashing the correct answer, by turning over the flash card, immediately after the attempt to recall, reproduce or recite. The simple verbal response of the group in concert may be a sufficient corrective to wrong responses.

The Buckingham problem solving test recognizes that psychologically it is more important at least at one stage of the learning process to analyze a problem than to solve it.

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[2] By making the terms on both disks identical we obtain not only all the permutations of terms but also n problems of the atypical sort. $(A+A)^2=?$; $(\beta_1+\beta_1)^2=?$

The teacher of mathematics is generally exasperated by the student's unwillingness to start. "If only he would do something, we could correct his errors." Such mental blocking is a symptom requiring the stimulus question, "what are some of the ways we could consider this; and what are some of the things that we could do?" If you have previously not thought of it, observe your students to see if there is not a high correlation between the speed of writing and the excellence of the thinking. Note, too, the mental blocking which results, as in the above problems, when they are unable to verbalize the curlicue designs. We are verbal creatures; when we can't verbalize, we can't think, at least for the most part.

When men in the army were asked to guess the answers to questions which they did not know, almost uniformly they refused. Students likewise refuse to put down any steps in a problem the end of which they cannot see, when obviously the problem is all but solved once full insight is attained. More students of mathematics are "visual minded" than realize it. Nothing facilitates thinking so much as some characters to look at. The world suffers less from bad thinking than from no thinking at all. Accordingly, the pupil should be encouraged to write his thoughts in symbols at once. Much of well taught mathematics is not thinking at all. As mathematics is now taught few students really learn that mathematical symbols are signs of operations. They will glibly quote some such statement as the above rule although their actions belie their comprehension of their parrot-like statements. They will not write

$$[(\ ) + (\ )]^2 = (\ )^2 + (\ )^2 + 2(\ )(\ )$$

to be filled in *at once*, and simplified *later* if necessary. I cannot over-emphasize the importance of this skeleton formula method of presentation. It emphasizes most highly the importance of putting down one step before thinking and doing the second and third.

It has been shown that the ability of students to acquire a rote memory mastery of materials, rules and crutches being discarded, is simply prodigious, provided the motivation for the learning be adequate. For example, Renshaw has shown that a large proportion of the class of sophomores working industriously on five separate occasions, a week apart, for twenty minutes on each occasion—100 minutes of practice in all—by such a study can work out for themselves without aid a method of

memorizing the order of a deck of well shuffled playing cards in a twenty minutes study of a deck. Thus half of the class, perhaps, in 100 minutes of motivated and distributed practice acquire self-taught methods of teaching themselves this startling vaudeville performance. The Hindu who mentally multiplied four place by four place numbers in an incredibly short period of time, confessed to having memorized the multiplication table to 100×100.

I have repeatedly shown in my classes that a majority of college juniors and seniors by concerted audible drill on the squares of numbers can learn to a point of one correct repetition the squares of all of the numbers up to 40 in about twenty minutes time. Of course, additional *use* is required in order to make the learning permanent. The important considerations are that the squares of the numbers shall be learned absolutely without crutches, which is to say, that the *order of presentation* of the numbers shall be truly random; that the student after being presented with a number, makes an effort to recall its square; that he shall be presented at once with the true response which he is attempting to establish; and that he not be allowed to make any progress whatsoever in a wrong response such as saying that the square of 38^2 is 1344 instead of the necessary 1444.

It is not certain that generalization and transfer will come about unless one makes specific effort to call to the student's mind the fact that for certain such generalization is possible and to reassure him not only that this is a verbal and logical sort of thing but *that it actually works*. Working the same problem *a number of times* in different ways and invariably arriving at the same result is often psychologically superior to working four separate problems. Differentiation of $\left(\frac{X^2 \cdot X^3}{X^2}\right)^4$ by all the simple rules of differentiation of product, powers and fractions is a case in point. It is quite a revelation to many even very good students to discover that the UV type of function will come out with the same result as the numerator-over-denominator type and that both of these are but special cases of the differentiation of a product raised to the p power. The bright students, of course, get such generalizations rather readily. I am inclined to believe that the big majority of students are not really brought to this point of proficiency, including the equally important point of *belief*.

Belief of the reasonableness of the rule is brought about as much by a large number of problem-solving experiences without exception as by logic. In other words logic is not particularly logical as far as the psychology of the matter is concerned. In my class of psychological statistics I find it exceedingly useful to use what I call degeneracy checks. The conditions of derivation of a statistical formula, once derived, are specialized and the student notes whether known familiar simpler formulae thereby can be derived from the greater generalisation which he has just solved. He is led to see the difference between a "numerical proof" and a "literal proof."

Mathematics is often called "dry" by the student. Perhaps mathematics is dry to many students. The student has not the background for progress which the instructor has. The idealization in mathematics is its undoing. It is too ideal. Perhaps it is not too much to ask that the problems be real live problems.

Much of the permanence of learning is dependent upon the intent of the student to remember. Such interest can be enlisted from concrete applications of intrinsic interest to the student. Compare this introduction to the straight line:[3]

$$T_F = .258C + 36.9°. \qquad N = 115.$$

where T = temperature Fahrenheit

C = cricket chirps per minute

with the conventional type of "Plot: $Y = 2X + 5$." What boy is not thrilled to know that you can add thirty-seven degrees to one-quarter of the cricket-chirps-per-minute and obtain the temperature (with a probable error of much less than one degree)?

The functional relationship is more important than the equation; or, rather, the thinking in functional terms about that relationship is highly important. From the former, one gains new concepts of law and orderliness about the universe; and something worth remembering as a cultural fact, as well as an insight into straight lines which surpasses that of the latter. The attitude is important. Consider these alternative statements of a problem:

(1) "Given the assumptions:

1. Sex is a chance phenomenon.
2. There are 20,000,000 families in the U. S.
3. One family out of 2000 has a family of 13 children. What

[3] Bert B. Holmes, Vocal Thermometers, *Scientific Monthly*, Sept. 1927, pp. 261–264.

is the expectancy of being able to obtain a picture of 13 children all of a given sex?"

(2) with this statement of the same problem:
"Here is a picture of 13 girls all of the same family. What is your guess as to the number of such pictures which could be "taken" in America?"

Expert understanding of mathematics and in particular the ability required in the trades and professions generally speaking means not merely superior technical confidence but superior judgment and estimating ability. Accordingly, it follows that if we attempt to train our students in estimating the results of equations we shall have, perhaps, established a more useful habit than that of solving equations. Neither, of course, is fair coin for the other, and it is still axiomatic that sandwiches require both cheese and bread.

Entirely too many problems of "How many men can dig a ditch" type are now given. No generalizations are frequently reached by the student that are worthy of the name. At the outset the student should be required to establish such equations in purely literal form. He should be made to feel the power and mastery of being able to solve *any* ditch problem "without thinking." I know that the difficulties are tremendous, but if one can induce the student to think of everyday things in literal and functional terms—even though he cannot derive or solve the formulae—one of the chief ends of mathematics has been attained. Let him make such verbal statements as "the intensity of light on a paper which is to be read varies with the size of the window space and inversely as the depth of the room," even though the statement of the function may be at fault! Or, "Inasmuch as the amount of gasoline in a filling station tank can be guessed by sticking a pole into the gasoline, so by a mathematical means of calibrating the stick the amount can be determined exactly, the calibrations being directly proportional to the integrated volume of liquid in a cylinder laid on its side." Or, "The rate at which ice melts in a refrigerator is proportional to the temperature and to the amount of surface exposed and consequently there is an optimal shape of ice cake" (even though the hunches may be wrong), etc. The world is eager for hunches, and even wrong hunches which may be investigated and destroyed. Generally speaking, those who think slowly are not deep thinkers; they simply are not thinkers at all!

One of the most useful methods of establishing the functional

thinking is by plotting families of curves, nomographic families. $Y=bX$ should be taught as a special case of $Y=a+bX$. And the latter should be taught, shortly, as a special case of $Y=a+bX+cX^2$. No method is so effective in such generalizations as curve plotting. We have much too little of it. Calculating machines and job analysis methods of solution make much curve plotting possible.

Compare too the motivating value of a problem of determining the equation for a line already drawn, as compared with the highly abstract problem of drawing a straight line to the two points: $P_1(3, 6)$ and $P_2(4, 9)$. Assuredly both abilities are needed but science and engineering have as many problems of curve fitting as of evaluating equations. The scientist's problem more often than not is to make a straight line fit three or five or fourteen points! In fact it is the ideal of the applied scientist to have all such equations as he frequently needs written into tables and nomographs in his handbooks.

The student is aware, for example, that there are few straight lines in nature and that curves occur far more frequently than straight lines; also that it is a multiple causation rather than single causation and single dependency which is the rule of the world. Is there any unreasonable reason why the straight line should not be taught in its nomographic relationships with at least two independent variables involved?

In the matter of accuracy, I believe that nothing but perfect accuracy, assuming that mortals can achieve such, is acceptable. To achieve such I have derived formulae for statistics to eliminate decimals, in most evaluations of formulae, until the very end result is reached, the final product usually being the quotient of an integral number by an integral denominator. All of the formulae of statistics practically without exception can be so reduced. Independent checking formulae are used wherever possible. These are simply a transformation of coordinates, of the type $X'=AX+b$, used in converting a thermometer reading on one scale to the corresponding reading on another. Belief in and use of the transforming system may be gained through two means: First, the transformed system is invariably easier to work with than the untransformed since decimals and negatives are thus avoided by running away from them; second, using a great many transformation systems on the same problem the student readily perceives, and so can be led to believe, that all the systems are consistent. He finally proves the general case

algebraically, once for all, and this belief is thereafter fixed. He does not need to be re-educated.

I likewise make much use of printed forms and skeleton formulae of which the following is an example,

$$R_{XY} = \frac{N \quad \Sigma XY \quad \Sigma X \quad \Sigma Y}{(\quad)\cdot(\quad)-(\quad)\cdot(\quad)}$$

$$\sqrt{\begin{matrix} N & \Sigma X^2 & \Sigma X \\ (\quad)\cdot(\quad)-(\quad)^2 \end{matrix}} \sqrt{\begin{matrix} N & \Sigma Y^2 & \Sigma Y \\ (\quad)\quad(\quad)-(\quad)^2 \end{matrix}}$$

These, coupled with calculating machines, free the student's mind for more important thinking. In many cases, the concept of job analysis and operator checks—column checks where a half dozen problems are simultaneously solved by the same formula—is an all important consideration in achieving habits of speed and accuracy. Little, for example, is gained by having the student write out twelve radicals in solving the above formula six times.

Our psychological tests show that students are woefully deficient in the ability to reason in the third dimension. Is this due to original nature or to the two-dimensional blackboard training which we give them? We can test this deficiency, popularly, by posing the celebrated problem of inquiry as to the shortest path to be taken by a wingless fly in traveling from the northeast lower corner of a room to the southwest upper corner of a room; or by the parlor puzzle of "Build four equilateral triangles out of six matches" or by "How would you build a house of regular geometrical pattern of more than one side with a window in every wall, and so designed that at any window you could obtain the desirable northern light over your left shoulder for reading?"

If it is possible to use stereoscopic projection and thus really obtain third dimensional presentations, it has real possibilities, it seems to me, in dealing with this weakness in the third dimension.[4] I cannot see how any mathematics department can function efficiently without a great many nomographic families of curves for the student's consideration and training.

The lack of orderly arrangement of work and consequent inability to do checking is one of the potent causes of computational error. The relative merits of the several methods of

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[4] Vuibert, H., *Les Anaglyphes Geometriques*, Paris, Libraire Vuibert, 1912, 32 pp.

checking should be taught; and, incidentally, the archaic "casting out the 9's" should be discouraged.

Finally, a compromise must be drawn between the number of life preservers given the student and the amount of imposed practice in paddling his own canoe employed in an effort to develop initiative, independence and thinking. The problem solves itself if we simply remember five precepts:

1. A maximum of motivated rote memory practice and a minimum of rules (perhaps even to the extent of a healthy contempt for "rules") will establish many mathematical habits on a motor habit basis.

2. Drill is not evil; and when employed we should strive to attain to *m*-fold efficiency.

3. Computation, likewise, should be done at *m*-fold efficiency. A maximum of functional analysis of problems divorced from computation leads to generality of insight.

4. The highest end to be sought is the attainment of and the appreciation of the beauty of the greatest possible number of generalizations which can be drawn.

"RAINBOWS" OF RARE METALS AID IN THEIR ANALYSIS

Measuring the minute quantity of a rare metal present in a mixture or alloy by means of the colors of its "rainbow" as photographed by the spectrograph, is the method of analysis reported before the meeting of the American Chemical Society by Drs. James G. Steed and Wallace R. Brode of Ohio State University.

When an element is heated until it gives off light, the various colors that make up that light can be split up into a spectrum and photographed. This method has been used in chemical analysis for many years. But until lately it was good only for telling what elements were present, not how much of each. Recently methods for estimating quantities as well as qualities were devised, and it is one of these methods that the two Ohio chemists have used in their studies.

They have analyzed "unknowns" containing small amounts of the steel-strengthening metals molybdenum, tungsten, vanadiam, titanium and tantalum, as well as the elements beryllium and columbium. The range of concentration they could determine by this "weighted rainbow" method was usually from two per cent down to five thousandths of one per cent, and in certain cases the limit was below one ten-thousandth of one per cent. —*Science Service.*

Every step of progress that has been made in the world has been accomplished through being willing to investigate and compare.—*Piprico News.*

The first step toward "getting on" is to make up your mind that you want to get on; then do whatever may be necessary to get on. Thinking and working will be of great assistance.—ULLERY.

SOME EDUCATIONAL IMPLICATIONS OF RECENT DEVELOPMENTS IN SCIENCE

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It is the purpose of the writer of this paper briefly to point out certain recent developments in science, to show how they have modified science education on the secondary level, and finally to suggest certain other ways in which this expanding scientific knowledge may affect education.

In his admirable little book, "Fundamental Concepts of Physics" Heyl (5) typifies the 18th century as a century of materialism and the 19th century as the century of correlation. He might, with equal justice, have antithetically styled the earlier period, in so far as science was concerned, as the century of separation. Concerned as they were with material objects and macrocosmic phenomena, it was, perhaps, only natural that differences, rather than similarities were stressed by the scientists of the period. Light was quite distinct from Mechanics. The Inorganic could have no vital connection with the Organic.

CORRELATION IN SCIENCE

It was only about a hundred years ago that Wöhler synthesized urea, a typical animal product, from ammonium cyanate, an equally typical inorganic substance. The results were far-reaching and violent. But as in that earlier, and equally disturbing experiment of the impetuous Galileo, the intellectual vested interests refused to accept the verdict of their senses. Instead they resorted to subterfuge in an attempt to rationalize their own evasion. Some even went so far as to attempt to explain away the whole experiment on the ground that the carbon must have retained a memory of the time when it was part of living matter—that the ammonium cyanate was simply a sort of metamorphic stage between two living phases—and hence that Wöhler had merely facilitated a change that would have taken place anyway. "Today one phenomenon after another which was at one time attributed to vital force is being traced to the action of the ordinary processes of physics and chemistry. Although the problem is still far from solution, it is becoming increasingly likely that what specially distinguished the matter of living bodies is the presence not of a 'vital force' but of the quite commonplace element, carbon, always in conjunction with

other atoms with which it forms exceptionally large molecules." (7–page 10.)

But while the barriers between the organic and the inorganic were being torn down, workers in other fields were not idle.

It was one of the Montgolfier brothers of balloon fame who first suggested that "force was not annihilated in mechanical changes, as the eighteenth century had taught, but was converted into heat, with a definite equivalent relation between them." (5)

Benjamin Thompson, Count Rumford, that somewhat bizarre Yankee, during the course of his meteoric career through European courts noticed that during the boring of cannons a quantity of heat was produced that seemed absurdly large in comparison to the weight of chips produced. Now at this time the caloric theory of heat was still generally held. According to this theory heat is a fluid contained in matter. Hence the amount of heat produced should have been directly proportional to the amount of chips. When, in an experiment, Rumford succeeded in making water boil by the friction of a blunt tool on a casting, the caloric theory received a set-back from which it never recovered.

Great scientific discoveries often seem to eventuate from chance. Darwin made a sea voyage, Oersted placed a wire over a compass needle, and in 1840, Robert Mayer, a German physician made a trip to Java as a ship surgeon. At that time bloodletting, always from a vein, was the universal medical cure-all. As a practicing physician, Mayer was familiar with the blood of a bluish tint found in the veins of Europeans. To his surprise, blood drawn from the vein of the arm of persons in Java was, almost without exception, of a bright red color. In his own words, "This phenomenon riveted my earliest attention. Starting from Lavoisier's theory according to which animal heat is the result of a process of combustion, I regarded the two-fold change in color which the blood undergoes in the capillaries as a sensible sign or visible indication of an oxidation going on in the blood. In order that the human body may be kept at a uniform temperature the development of heat within it must bear a quantitative relation to the heat which it loses, a relation that is determined by the temperature of the surrounding medium; and hence-forth the production of heat and the process of oxidation as well as the difference in the color of the two kinds of blood must be on the whole less in the torrid zones than in the colder regions." (3—page 117.)

In other words the higher temperature in the tropics caused a reduction of the rate of oxidation. This reduced rate of oxidation manifested itself in the very small difference in color between arterial and venous blood. That is, there is a fixed, quantitative relationship between "wear and tear," as Mayer called it, and the heat evolved.

Then, using Regnaults tables of the specific heat of gases Mayer calculated the amount of work done by an expanding gas as it absorbed a certain amount of heat. When allowances are made for the inaccuracies of Regnault's value, Mayer's results agree almost perfectly with those of Joule, whose name recalls his numerous experimental determinations of the mechanical equivalent of heat.

Space does not permit a complete discussion of the work of this thwarted Manchester brewer. (He had wanted to be a college professor.) Suffice to say Joule proved in many ways that when a given amount of mechanical energy is used up, a fixed amount of heat is always produced.

Thus was one of the most important correlations—that between mechanical work and heat—established.

In 1800 Alessandro Volta announced the results of 17 years of experimentation—the invention of his "Voltaic pile." A steady electric current had been produced. Nineteen years later, Hans Christian Oersted, man of genius but most awkward of experimenters, at the close of one of his lectures, "placed the wire from a heavy galvanic battery over and parallel with a compass needle upon his desk. He was amazed to see the needle swing through a large arc and place itself at right angles to the wire. He reversed the direction of the current and the needle promptly swung to the opposite side." (3—page 151.)

Oersted had shown that an electric current possesses a magnetic field. If such be the case, the opposite should also be true. A magnetic field should be able to produce an electric current. One day in August, 1831, Michael Faraday wound on a soft iron ring, six inches in diameter, two coils of wire, each on a separate portion of the ring. One coil he connected to a battery and key; the other coil to a galvanometer. When he closed the circuit, the galvanometer deflected momentarily. Again, when he released the key the galvanometer deflected, this time in the opposite direction. A magnetic field had produced an electric current. Magnetism and electricity are correlated.

One after another, the hard and fast barriers between science

phenomena came tumbling down. Previously, in 1822, Seebeck had discovered that two metals such as copper and bismuth, will produce an electric current through a galvanometer when the two wires are twisted together and heated. In 1873 James Clerk Maxwell published his monumental treatise "Electricity and Magnetism." He had "sought and found a beautiful scheme of thought in which to comprehend and harmonize the discoveries of his predecessors. The form of his scheme was such as to suggest that it should be possible to propagate electro-magnetic disturbances in the form of waves in an all-pervading medium, and that certain of these waves should have the properties of light waves, and that all should travel with a velocity equal to that of light. His conclusions in the latter respects were beautifully verified by his calculations of the correct velocity of light from purely electrical data, and his predictions in the former, have received wonderful justification, first in the experimental work of Hertz and Lodge, and finally in the modern developments of wireless telegraphy and telephony in the hands of Marconi and others, ... We now know that the electromagnetic waves of wireless, heat rays, light rays, the ultra-violet rays used therapeutically, X-rays, the gamma rays emitted by radium, . . . are all special cases of electro-magnetic waves differing from each other in their essentials only as regards their length." (12—pages 239–240.) Thus was the correlation between electricity and light established and the whole vista of the electromagnetic spectrum displayed.

With the passing of Maxwell came one of those seemingly unaccountable pauses in scientific progress—a time when the pulse of scientific endeavor beat with a diminished intensity—"a time when would-be Ph.D.'s went about like roaring lions, seeking something to measure and finding nothing but the density of a gas or the viscosity of a solid. The sentiment of the times was well voiced by a certain European physicist of eminence who stated that it was probable that all the important experimental discoveries in physics had then been made and that henceforth the investigator must confine himself to a repetition of what had been already done with greater attention to minor matters of precision." (12)

And then on Christmas eve, 1895, Röntgen presented his first X-ray photographs. "Here was a completely new phenomenon —a qualitatively new discovery and one having nothing to do with principles of exact measurement." (9)

Less than a year later came the discovery of radioactivity and the props were knocked from under the almost smugly satisfactory picture of the physical world. A tenet held with almost religious intensity had been that of the permanence of the chemical elements. Radioactivity forced a revision of this belief. A renewed interest in research and a new picture of the physical world were the result. And when, in 1898, J. J. Thomson discovered the electron, another great correlation, that of the electrical nature of matter was well on its way to establishment.

One more important correlation (that between matter and energy) and our list, while not complete, is sufficiently representative. It had been difficult for scientists and laymen alike to accept the implications of the work of Joule and Mayer on the mechanical equivalent of heat. How much more difficult has it been for them to accept the principle of the equivalence of matter and energy—a principle which was stated by Einstein only about a quarter of a century ago. As Heyl puts it, "The conservative citizens of the domain, while acknowledging the sovereignty of energy, always retained in their hearts a special feeling of respect for matter as the ultimate reality, the substance of things, whose existence permitted energy to be, and without which energy would be but an empty name." (6—page 70.)

We have shown how the correlations existing between the various forms of energy were established. And now matter, itself, is alleged to be but another form of energy. Joule had shown experimentally that when 4.27×10^7 ergs of energy are used up, one calorie of heat is produced. Einstein showed that if one gram of matter—solid, liquid, or gas—heaviest solid or lightest gas—if one gram of any substance disappears in producing energy, 9×10^{20} ergs of energy appear. "The combustion of a ton of the best coal in pure oxygen, liberates about 5×10^{16} ergs of energy; the annihilation of a ton of coal liberates 9×10^{26} ergs which is 18,000 million times as much. . . . If we on earth could burn our coal as completely as this, a single pound would keep the whole British nation going for a fortnight, domestic fires, factories, trains, power-stations, ships and all; a piece of coal smaller than a pea would take the Mauretania across the Atlantic and back." (8—pages 180–181.)

CORRELATION AND SCIENCE EDUCATION

We have seen how one of the major trends in science research

for the past hundred years has been toward the correlating of phenomena in what had heretofore been separate fields. Has this trend had any effect upon science education in the past and what are its implications for the future?

A typical high school curriculum of thirty or so years ago would have included separate courses in botany, zoology, physiology, chemistry, physics, physiography (now practically extinct as a high school subject) and possibly several other science subjects. General Science was unheard of. Since that time a course in general biology has been developed and has replaced the three special biological sciences in high school curricula. About the time that Einstein's revolutionary pronouncement on the equivalence of matter and energy was made, the first courses in General Science were being developed. The development of these two subjects illustrates the operation of the tendency toward unification which we have seen at work in the field of science research. General biology and general science were developed with the idea of bringing together those elements which are needed to develop a concept, whether or not these elements are drawn from more than one field of science. They are integrated sciences.

With physics and chemistry, the physical sciences, other forces were at work. In 1872, with the recognition of the subject, physics, as one suitable for college entrance credit, the colleges hastened the disappearance of Natural Philosophy from secondary school curricula. Natural Philosophy had been an attempt to explain the phenomena of the environment. Physics became a subject which would be acceptable to the college authorities. In order to make it so, physics was modeled as closely as possible after the courses offered by its mentors and became a diluted college course in physics. A similar development took place with chemistry when, a few years later, it too came under the control of the colleges. The right to select the materials of instruction for secondary sciences came to rest largely with the subject-matter specialists of the institutions of higher education. Now subject-matter specialists are notoriously victims of that form of educational myopia which renders them largely blind to the instructional values of subjects outside the field of their specialization. Hence high school courses in physics and chemistry came increasingly to include only those topics which, by virtue of long prescription could unmistakably be classified in these special science fields.

It is an interesting speculation as to what course the development of the physical sciences would have taken, had this external control been absent. The biological sciences, always freer from college domination than the physical sciences, were able to take their cue from the developments of scientific knowledge. An integrated biology was the result. Would a similar development have taken place in the physical sciences? It is significant that, in spite of college domination, certain portions of physics and chemistry are becoming less and less distinguishable. This has been brought by changes in the body of subject matter of physics and chemistry themselves, rather than by conscious planning. The electrical nature of matter is discovered and it is realized that both chemical change and the phenomena of current electricity are best explained in terms of electrons and electron motion. As the result of this and other discoveries, certain portions of chemistry and physics texts are becoming virtually indistinguishable. A rapid count of the index of any modern high-school chemistry text discloses topics such as the storage battery, the dry-cell, electrolysis, radio-activity, the effect of dissolved material on the boiling and freezing points of water, the photo-electric effect, the barometer, Boyle's Law, the spectroscope and spectrum analysis, relative humidity, fluorescence, electron theory, density and specific gravity, refrigeration and others which, to a greater or lesser degree, are treated in physics texts as well as in the book under examination. Developing from within the subjects themselves have come forces which are continually operating to break down the barriers between physics and chemistry. Opposed to this tendency are the outside controls of the colleges which continually operate to keep the subjects in the traditional groove. The story of the physical sciences in the secondary schools in the next few years will be, almost unquestionably, one of increased integration. It is not within the province of this paper to attempt to set forth what the high school physical science of the future should be, however. Suffice to say, the tendency toward integration, illustrated by the development of science itself, which resulted in the evolution of integrated biology and General Science courses, was thwarted in the case of the physical sciences by the imposition of arbitrary standards from above. Such integration as has taken place in the physical sciences has been forced by new findings in the subject matter itself, not by a conscious attempt in that direction.

THEORIES IN SCIENCE EDUCATION

Keeping pace with increasing scientific knowledge has come an increasing tendency to use this knowledge to explain certain phenomena discussed in high-school science courses. Successive editions of popular texts for secondary school use carry an increasing number of pages devoted to the presentation of the latest information about the structure of the atom, the periodic table, the dual nature of light. There is no gainsaying the fact that all this theory has been extremely successful in explaining phenomena. High school students speak glibly enough about the atom, electronic orbits, and of many other such matters which were unheard of a generation ago. There may be, however, some undesirable aspects of this situation. Scientists have not failed to note the arbitrary natures of some certain assumptions about the atom. Thus, speaking of the Bohr atom, Heyl says, "The arbitrariness and inconsistency of these fundamental assumptions no one was readier to admit than Bohr, himself. His justification for them was that they worked well, and they certainly did. . . . Upon the basis of these untenable assumptions, Bohr and his fellow-workers erected a statue marvelously true to Nature; yet this statue had feet of clay. It was doomed to fall whenever a more consistent and at least equally efficient substitute should make its appearance." (6—page 25.)

The implications of science are clear. Science teachers should not regard these theories as facts and should be extremely careful not to create the impression that they are facts. The mere repeated use of theories in high school science may create this impression even although neither text or teacher make any such claim. To be merely careful not to claim too much for these theories is not sufficient. Their use must be continually safeguarded by statements, discussions, to create the clear-cut impression in the minds of students that here are no facts, established beyond the chance of disproof, but simply theories, useful to the extent that they explain phenomena and help to predict new phenomena, but of little value in themselves.

It follows then that theories should be brought into a high-school science course only as they function in explaining phenomena with which the students are, or may become, conversant. Certain simpler aspects of the quantum theory are well within the limits of understanding of high-school students. On a criterion of frequency of occurrence in recent popular books on science, their inclusion would seem to be called for. Not-

withstanding, unless students are familiarized with fluorescence, the photoelectric effect and possibly certain other quantum phenomena, there is little justification for any discussion of this theory. These phenomena are of sufficient importance to present in a high-school physics course. The apparatus to demonstrate them is available to all science teachers. (It requires only an electroscope, a rubber rod, a piece of fur, a piece of zinc and an electric arc to demonstrate the photoelectric effect). The quantum theory is adduced to explain this, and other phenomena—and is omitted if the phenomena are omitted.

IMPLICATIONS FOR EDUCATION IN GENERAL

These are some of the implications of expanding scientific knowledge for science education. Many more there must be. Such practical questions as, "To what extent are the methods of science applicable to science teaching?"; "What bearing do the findings of science have on the puzzling question of the use of the laboratory?"; "What is the proper integrated science program extending from the kindergarten to grade 12?"—and many others come to mind. Space does not permit their discussion at this time. There are, however, certain philosophical implications for the field of education in general, that demand attention.

It may seem at first thought that any attempt to give a high-school student a philosophical background is a step backward—a step toward the time when educators were making all sorts of preposterous claims for the educational values of science—toward the time (and it is not so many years ago) when it was possible for the Fourth Yearbook of the Department of Superintendence to claim that 18 of 72 objectives for elementary science are realized by the activity "feeding squirrels"—toward the days of the Seven Cardinal Principals of Education. It remains to be proved that such need be the case. The Seven Cardinal Principles are a statement, incomplete though they may be, of the philosophy of education and educators. I am thinking of the personal philosophy of a modern high-school student. Does science have anything to contribute?

Until our minds became obsessed with our present economic dilemma, a popular theme for discussion was some phase of the upheaval within the social order. The control of the home had broken down, we said. The influence of the church is waning. The youth of the land are restless, even almost rebellious. The

causes of whatever degree of demoralization existed, and may still exist, are undoubtedly extremely numerous and in some cases extremely obscure. I believe it to be a tenable hypothesis that part of this change may be charged to the disappearance of the old "certainties." For this science is probably partly responsible. Margaret Mead studied a primitive society in the South Seas and noticed that the "Sturm und Drang" period, so commonly associated with adolescence in our own society is almost completely missing. She suggests that this may be due, in part at least, to the fact that young people in Samoa are not taught as facts things which, in later life, they may be forced to re-evaluate or completely reject. In our society we are not so careful. We still dogmatize to our children. We still inculcate the old bugaboos, the old mistaken loyalties. Science is often the agency which produces a sceptical attitude towards these dogmas through its revelation of facts inconsistent with the old anthropomorphic and egocentric view of the universe. And this is no other than right. There should be no temporizing with or withholding of, the facts of science (first being sure they really are facts) because of any fear of possible effects. Does this mean, then, that science education should shoulder the responsibility of going beyond the mere presentation of its body of knowledge to an indication of certain philosophical implications of this knowledge? I think so. This does not indicate, however, that science education shall include the teaching of attitudes. Such practice savors too much of indoctrination. Instead let us present the facts of science and show how these facts have profoundly affected the thinking and personal philosophy of men the world over. Let this be done without any indication that all should be affected in the same way. Though fear of causing offense, or because of a *laissez faire* attitude, science education has held back from attempting to show these implications. The time has come, however, when the step should be taken, although the length and direction of that step may not be clear at present. It becomes important, then to find what some of these philosophical implications are.

First, and perhaps most important, is the idea that "Man's conception of truth changes"—not truth itself, but the thing which, for lack of more complete information, man has thought of as the truth. Perhaps no better example of the forced revision of long-held notions is found than in the story of the development of the quantum theory. As Swann (12) puts it, "Happily,

the complacency of our outlook has received in recent years one or two serious jolts. First came the theory of relativity, which taught us that a greater elasticity of thought was necessary if we were to understand nature as she is rather than as we might have made her. Then came a series of experimental phenomena which seemed to violate all our notions of how things should be, and since we could not alter the experimental phenomena we had to alter the notions, and so there arose the quantum theory of atomic structure—one of the most helpful crystallizations of thought for correlating the facts that we have ever had." The history of science is studded with many such instances where men have been willing to accept the findings of science, and to revise long-held and cherished notions even although such a step caused more than a little of personal inconvenience. It is this willingness to adjust our own pet ideas and prejudices to meet new facts and ideas that is needed today.

A second implication is that arising from our knowledge of the universe. To the early Greeks the earth was the motionless center of the universe—a universe bounded by the fixed stars which moved around the earth as a center. A few hardy souls, notably Aristarchus in the third century B.C. were so bold as to suggest that the apparent rotation of the heavenly bodies might be due to the revolution of the earth. But "for nearly two thousand years more the earth lay motionless in the minds of its inhabitants" (1)

With Copernicus came the change. In 1543 that Polish astronomer set forth his theory of the moving earth with sufficient cogency to gain an acceptance. And yet the wrench could not have been too great. True the earth was no longer the center of the universe. But the universe was not necessarily vast. Furthermore was not the sun, whose rays warmed the earth and who watched benignantly over its brood of planets, the center of the universe? All was still right in the best of worlds, in the best of universes. The universe was still made for man.

How different is the picture of the universe today. We vision a universe of an extent vast beyond conception. "Our first impression is something akin to terror. We find the universe terrifying because of its vast meaningless distances, terrifying because of its inconceivably long vistas of time which dwarf human history to the twinkling of an eye, terrifying because of our extreme loneliness, and because of the material insignificance of our home in space—a millionth part of a grain of sand

out of all the seasand in the world. But above all else, we find the universe terrifying because it appears to be indifferent to life like our own; emotion, ambition and achievement, art and religion all seem equally foreign to its plan. Perhaps indeed we ought to say it appears to be actively hostile to life like our own. For the most part, empty space is so cold that all life in it would be frozen; most of the matter in space is so hot as to make life on it impossible; space is traversed, and astronomical bodies continually bombarded, by radiation of a variety of kinds much of which is probably inimical to, or even destructive of, life" (7—page 3).

To a young person, brought up on the theological pap of a paternalistic religion, the effects of the presentation of such a picture of the universe cannot be other than devastating. The existence of a benignant, all-wise Ruler of the universe becomes doubtful. Some may banish him altogether. Others replace him by a "sadistic Despot" (13). Immortality, too, in the ordinary sense, becomes unthinkable. The whole purpose of life becomes uncertain. We ask, with Jeans, "Is this, then all that life amounts to? To stumble, almost by mistake, into a universe which was clearly not designed for life, and which, to all appearances, is either totally indifferent or definitely hostile to it, to stay clinging on to a fragment of a grain of sand until we are frozen off, to strut our tiny hour on our tiny stage with the knowledge that our aspirations are all doomed to final frustration, and that our achievements must perish with our race, leaving the universe as though we had never been?" (7—page 15.)

Before the passage of the old certainties a certain amount of motivation for the "good life" may have come from the fear of punishment and from the hope of reward in a life after death. To many, the promise of a seraphic future life, dangling before their eyes, helped to erase memories of the injustices and sufferings of the present life. Whether this lure may not have operated in many cases to make people the world over supine and bewildered, under conditions which an intelligent belligerency might have alleviated need not be discussed here.

But what are the implications of all this for education? Do these metaphysical and philosophical questions have any bearing on the field of secondary education in particular? Again, the answer is "Yes." Peculiarly so, since for obvious reasons religious education has not, and probably cannot, meet this issue. After all, one does not deliberately sow the seeds of one's own

destruction. Furthermore religious education, formally conceived, does not influence a sufficiently large proportion of the youth of the land to warrant entrusting the whole matter in its hands.

It becomes, then, the task of public education to teach the facts of science accurately, completely and fearlessly and to accept the implications of this teaching without evasion. It becomes necessary to educate for a life motivated largely by conceptions of the social good, without fear of future punishment or hope of future reward. It is, after all, probably "nobler" to lead the kind of life we have called "Christian" because we realize it is the only life compatible with the good of the social order, than because we hope by this process to escape eternal fires or to win a place in the heavenly choir.

I do not wish to seem to overlook the difficulties of such education. It requires a depth of character, not too easy of development, that accepts life as an end unto itself. "The more puerile a man's personality, the less calmly can he contemplate its extinction. To look upon death as extinction and still to meet it philosophically is a state of mind he can scarcely credit." (13) Neither am I sure which departments or subjects shall accept the responsibility for this education. One thing, only is certain. The mandate of science brooks no denial. It does not require that education shall engage in any program of teaching disbelief in current religious dogma. It does require that education shall prepare students to meet the challenge to such dogma that expanding scientific knowledge offers.

From certain considerations growing out of the quantum theory, Heisenberg and others have developed the "principle of indeterminancy" which states that "a particle may have position or it may have velocity, but it cannot in any exact sense have both" (4—page 220). For example, the speed of an electron may be measured accurately but then its position becomes uncertain, or if we attempt to locate it accurately, we thereby make it impossible to determine its velocity with precision. Upon this simple, physical statement, the interpretation has been placed, by some, that the old physical laws of cause and effect no longer are valid. Eddington, for example, makes this law the basis for his stand on the matter of human free will. "The future is a combination of the causal influences of the past together with unpredictable elements—unpredictable not merely because it is impracticable to obtain the data of predic-

tion but because no data connected causally with our experience exist. . . . science thereby withdraws its moral opposition to free-will." (4—pages 294–5.)

Thus a simple statement about the impossibility of measuring accurately the status of individual particles, has been made the basis of the most amazing philosophical interpretations. Clergymen have eagerly seized upon it as an "escape from the thralldom to mathematical laws." (11—page 104.) Even so great a scientist as A. H. Compton, did not hesitate to give it such an interpretation in his recent lectures at the College of the City of New York (1930). Nowhere do we find otherwise great scientists being so unscientific as in their eagerness to place an interpretation on this principle that will be a sop to the Cerberus of perplexed laity.

However, this has not been without dissenting voices. J. E. Turner, writing in *Nature* (Dec. 27, 1930) says, "The use to which the Principle of Indeterminancy has been put is largely due to an ambiguity in the word "determined." . . . Every argument that, since some change cannot be 'determined' in the sense of 'ascertained,' it is therefore not 'determined' in the absolutely different sense of 'caused' is a fallacy of equivocation."

Russell (11—page 106) points out that "Eddington's view, similarly, is at the mercy of experimental physicists, who may at any moment discover laws regulating the behavior of individual atoms. It is very rash to erect a theological super-structure upon a piece of ignorance which may be only momentary. And the effects of this procedure, so far as it has any, are necessarily bad since they make men hope that new discoveries will not be made."

Planck (10, page 51) notes that "there are eminent physicists who . . . are inclined to sacrifice the principle of strict causality in the physical view of the world. . . . So far as I can see, however, there is no ground for such a renunciation." And Einstein (*Nature*, Mar. 26, 1927) urges, "May the spirit of Newton's method give us the power to restore unison between physical reality and the profoundest characteristic of Newton's teaching —strict causality."

The implications of all this for education are not clear. It is easier to say what it does *not* mean, than what it does. Whichever point of view may prevail—that of Eddington and Compton or that expressed in the latter four quotations, one thing

seems clear. The Principle of Indeterminancy contains no mandate to education to throw over the law of cause and effect. Such prevalent manifestations of a naïve public will toward the mystical and supernatural as the present craze for numerology, palmistry, and the like, illustrate the supreme importance of inculcating the idea of true cause and effect and the scientific method. After all, the Principle of Indeterminancy deals with microcosmic rather than with macroscosmic phenomena. The old laws still hold in the affairs of ordinary life. We can safely leave the interpretation of this principle to the layman until such time as its implications are more thoroughly understood by scientists themselves.

And finally. No one will question the value of attempting to ascertain the implication for education of our rapidly expanding scientific knowledge. The developments discussed in the earlier part of this paper carry their own implications as an open book for all to read. Who shall say what they are in the case of the Principle of Indeterminancy, since science itself is not sure as to its meaning? Science education, and education in general, will do well to sit at the feet of Science and to listen carefully to her sayings. But let these words be studied carefully and weighed accurately, lest Education once again be guilty of following a will-of-the-wisp.

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SCIENTISTS LISTEN IN ON KATYDID'S HEARING APPARATUS

A katydid's knees, which are that creature's own peculiar "ears," have given men the novel experience of listening in on that insect's world of sound.

The story of how scientists have tapped the hearing circuit of katydids and crickets by placing electrodes against the knees of the insects, amplifying the responses picked up, and listening in on these in an ordinary telephone receiver, was related to the meeting of the New York Branch, American Psychological Association, by Drs. E. G. Wever and C. W. Bray, of Princeton University.

The resulting sound was always a sort of "shushing" noise, regardless of the source of the sound. Human speech lost all characteristic qualities except the rhythm, which was preserved.

But the katydid is apparently deaf to the ordinary sounds of our world and hears principally those that are beyond the reach of human ears. Sounds of frequency below 800 cycles produced no response even when very loud. But the higher frequencies, even up to 45,000 cycles per second were picked up. The limit of man's hearing is usually about 20,000 cycles —the shrillest note of the peanut whistle.

Results for the crickets were similar, except that his hearing range is apparently between 500 cycles and 11,000 cycles, considerably lower than that of the katydid and with an upper limit considerably below that of man.

—*Science Service*

GOLD FOUND IN AMERICAN TOMBS STIMULATES PROSPECTING

Renewed mining activities in Oaxaca during the last few months are ascribed by many persons to the discovery of ancient gold in Monte Alban earlier in the year. The fall of silver in world markets recently brought mining practically to a standstill in Oaxaca, but prospectors are now busy again, but looking for gold. Many mines closed because of the Mexican revolutions of the last twenty years are being reconsidered.

The archaeological explorations of Monte Alban are believed to have redirected mining attention on Oaxaca to some extent, for promoters believe that where there was old gold there must be new. The ancient Mixtec king of Tututepec near the Pacific coast of Oaxaca had the reputation of being the richest king in gold in Mexico. In 1524 the conquistador, Alvarado, ordered the Indians there to make him spurs of gold like his Spanish ones of iron and also a gold chain for his neck, but the chain was so heavy that he gave it to his horse.

SOME SUGGESTIONS FOR USING AMATEUR PHOTOGRAPHY IN MATHEMATICS COURSES

By T. L. Engle

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It is necessary for all teachers to be constantly on the lookout for methods and devices which will help to motivate their pupils, but this need for motivation is especially great in such an abstract subject as mathematics. Intense interest in hobbies is one characteristic of adolescence, and in any high school group there are likely to be several who are very much interested in the wholesome and instructive hobby of amateur photography. Practice of this hobby need not be limited to the mere snapping of commonplace pictures, and those truly interested in it will welcome suggestions for doing something unusual. The amateur photography suggestions given below will not only provide motivation by taking mathematics outside of the text books, but will also help to link mathematics with other sciences, and may lay a foundation for a permanent interest in the subject.

Due to hearsay many pupils enter plane geometry with the firm belief that they are not going to like it. They have been told that it is very difficult and that there are no "practical" applications. The newer texts make a definite effort to overcome this prejudice during the first few lessons and to hold the interest by calling attention to examples of geometric figures and principles in everyday situations outside of the classroom. The amateur photographer can be set to work obtaining pictures illustrating symmetry, circular and Gothic windows, compound curves, eccentric and concentric circles, proportion, similarity, triangular bracing, parabolas formed by suspended cables, and so forth, from the fields of architectural and structural design. Not only is his interest aroused but his fellow pupils will be more interested in these local pictures than in those in a textbook.

One of the most difficult concepts to present in plane geometry is that of the locus. Any camera, box or folding, equipped with a shutter capable of taking time exposures can be used to obtain paths of moving points. Any bright light may be used for the moving point, but the writer has found that a carbide light, for example a miner's light or a bicycle lamp without lense, is sufficiently white and bright to effect a negative. Also,

a piece of burning magnesium ribbon will provide an excellent light. Of course such pictures should be taken at night or in a dark room. A circle as the path of a point moving at a given distance from a fixed point can be obtained by fastening a light on one end of a stick, the other end of which is pivoted. As the light is revolved about the pivot a circle is traced on the negative. By tossing some object to which has been attached a piece of burning magnesium ribbon into the air within range of an open camera an approximate parabola can be obtained. Skyrockets containing white light may be photographed to illustrate the same curve, but those containing mostly yellow and red lights will not show up well. The above pictures can be used not only in plane geometry, but they can be used in algebra and solid geometry when the conic sections are studied.

Although the cycloid is not discussed ordinarily in secondary school mathematics it can be used to illustrate the locus. It is always interesting to ask a class of high school pupils, or even adults who have not studied higher mathematics, to draw the path of a point on the circumference of a wheel as the wheel rolls along a straight line. Very few will even approximate the cycloid and some of the curves drawn are often quite humorous. If a bright light, for example a piece of burning magnesium ribbon, is fastened to a wheel and the wheel is rolled along a straight line parallel to an open camera, a very definite and conclusive proof of the path can be obtained. If one wishes to branch out, the hypocycloid and epicycloid may be obtained with a camera.

At the present time many high school pupils are keenly interested in aviation. A camera mounted on a tripod and set for time will catch some interesting curves if focused on an airplane carrying flares.

Many pupils will be surprised to learn that the path of a moving point is sometimes used to secure increased efficiency in industry. In certain kinds of work such as assembling small units or machine work a workman must make the same movements many times during a day. Any useless movements in an operation that is repeated many times causes a distinct lowering of efficiency. In order to detect useless or excessive movements the following technique is used sometimes. A small but bright electric light bulb which is connected to a battery or other source of current by a flexible wire is fastened on the back of a workman's hand. He then works in a somewhat darkened room in

front of an open camera. Time is allowed for the completion of a given operation. When the film is developed and printed a white line or series of lines shows exactly how the workman moved in performing his task. In cases where the lines are unnecessarily long the workman is taught to improve his skill by shortening his movements, or his efficiency may be increased by rearrangement of his equipment.

It is only in the lower branches that mathematics and astronomy are divorced, and as teachers of mathematics we can do much to motivate our pupils and provide lasting interests for them by turning their attention to the celestial sphere. The path of the moon can be obtained by means of a time exposure of several hours on any bright moonlight night. A box camera may be used, but a camera which can be stopped down will secure a much sharper path. If fleeting clouds happen to cover the moon occasionally they merely add interest to the picture by leaving their permanent record on the film. Most people think that the stars cannot be photographed by an amateur, but although stars as fixed points cannot be obtained without astronomical equipment their paths can be obtained by any amateur. One needs to be in the country or on a high building in order to get away from street lights. The apparent circular rotation of the stars about Polaris can be obtained by pointing the camera at the Pole star and allowing a long exposure. Two hours will show the arcs, but a five- or six-hour exposure will provide very convincing evidence. Rules on amateur photography have so much to say about facing the sun that most people would not think of daring to point a camera directly at the sun, but some very interesting pictures may be obtained by doing so. A continuous exposure to the sun will give a negative too dense for use, but the apparent path across the sky can be obtained by mounting the camera on a tripod and taking a series of exposures on the same film at frequent intervals, for example, every ten minutes. A ray filter may be used but good pictures of the sun can be obtained without its use by stopping down the camera as much as possible and giving as short an exposure as possible. Using a rapid rectilinear lense, f-64, 1/100 second, the writer obtained a very interesting series of pictures of the 1932 eclipse of the sun. Eclipses of the moon may be taken by giving a longer exposure and using a larger stop than would be used for the sun. Eclipses are of popular interest and provide an excellent opportunity for applying elementary mathematics to astronomy.

The true amateur photographer finds much of the enjoyment of his hobby in the developing and printing of his own pictures. If sent to a professional for the usual amateur work most of the negatives obtained above would be returned without prints. In making prints of the stars a very short exposure must be given and then they must be brought up slowly in the developer, otherwise nothing but black will appear. On the other hand, pictures of the sun must be given very long exposures in order to eliminate all light except the bright disk. The writer has found that a seven or eight minute exposure to a 75 watt light is not too long for sun prints. All of the suggested pictures can be obtained with much better results in the home amateur laboratory than by sending them to the usual careless professional work shop.

Lantern slides of any of these pictures will make them more readily available for classroom use or will provide excellent material for a mathematics club program. Many amateurs will be surprised to learn that lantern slides are but very little more difficult to make than ordinary paper prints. Plates, cover glasses, mats, and binding tape may be obtained from any photographic supply house. Slides need not cost over ten cents apiece by doing one's own work with care, although the beginner may run up the cost of the first few through spoiled plates. Slides are printed in exactly the same manner as paper prints except that exposure is much shorter. The light of an ordinary match burning within two feet of the plate or a 25 watt electric light at a distance of six feet for about five seconds is sufficient for normal negatives. Slides may be tinted with the same transparent water coloring materials used for paper.

Pupils become so accustomed to thinking in terms of plane figures that the greatest difficulty in beginning work in solid geometry is learning to think in terms of three dimensions. Without going into the psychology of space perception it can be explained to a class that one factor in our perception of the third dimension is that our two eyes focus on any given object at slightly different angles. Stereoscope pictures are able to show three dimensions by using this principle. Stereoscopic cameras are available with two lenses set apart at a distance equal to the average interocular distance and so arranged that they will take two pictures simultaneously. Most amateur photographers do not possess such a camera, but one is not necessary in order to obtain stereoscope pictures. Any camera can be placed on a ta-

ble, one picture taken, then the camera moved about three inches along a straight line parallel to the object being photographed, and another picture taken. If the resulting pictures are mounted side by side (a little experimenting will enable one to find the correct placement) and are viewed through a stereoscope the three dimensions are clear. Such pictures taken of geometric models or other objects will help to develop an understanding of the relationship between pictures of solid objects drawn on a plane surface and their three dimensional originals. With the development of this understanding much of the difficulty in solid geometry has been overcome. A little fun can be added by moving the camera more than three inches, for example thirty inches, between exposures. The result when viewed through a stereoscope will be a picture in which two dimensions are normal but in which the depth is greatly exaggerated. A picture of an automobile taken in this way gives a car far too wide for use on city streets. If two cameras are used with an exaggerated interocular distance, a ludicrous picture of an individual can be obtained.

No attempt has been made to list all possible ways in which amateur photography can be used to provide motivation in mathematics courses, but it is hoped that the above suggestions will prove to be helpful and stimulating.

MORE MATHEMATICS DECLARED GREAT NEED OF CHEMISTRY

Chemistry looks toward the young scientists to work the same revolution in its outlook and methods that they have already brought about in the field of physics. Chemistry must have its Einsteins, its de Broglies, its Lemaitres.

This was part of the message brought to the opening session of the American Chemical Society's spring meeting by Prof. Hugh S. Taylor of Princeton University.

"Chemistry," said Prof. Taylor, "is still largely a descriptive, observational, and empirical science. We cannot be well content until the time comes when chemistry is far greater than such a collection of empirical facts.

"We look forward to a more complete mastery of these facts in terms of a more comprehensive theoretical treatment which underlies them all. We shall learn to understand, with insight and forevision, the fundamental bases upon which all knowledge of reactions and reaction rates, of stereochemistry and valence, of analysis and synthesis, upon which our towering structure rests.

"To the building of such a structure we can gladly welcome our youth to further toil and effort. We should encourage them to undertake the task with broader horizons in science, in philosophy, and in literature than we ourselves brought to our work."—*Science Service.*

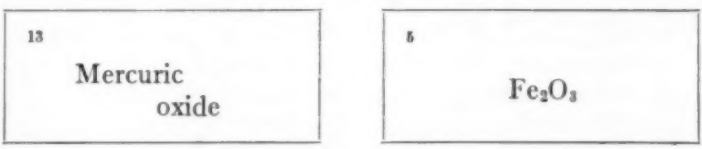
HELPING THE CHEMISTRY BEGINNER GRASP FORMULAS AND NOMENCLATURE FLASH CARDS

By Francis C. Coulson
Crane High School, Chicago

Formulas are troublesome to most chemistry beginners. Inadequate knowledge of writing formulas from names of compounds presupposes a troublesome procedure for equation writing and those two conditions will very likely discourage considerably the chemistry beginner. In a previous article (1) it was mentioned that formulas and equations could be put over in an excellent manner by the use of the activity series of the metals beginning with the study of oxygen and hydrogen. The pupil should be required to memorize the symbol and common valences of each element in the series. Only slight reference was made in the article about the use of a very valuable aid to clinching formulas, namely, the aid of flash cards. It is the purpose of this article to give some detail about the nature and use of the formula and name flash cards which others may find helpful.

CARD-MAKEUP

Fairly stiff white cardboard is suitable. A standard size, 4 inches by 11 inches will allow sufficient room for the longest names of the compounds. For the words, 8-line type will be visible enough from the back of the room while, for the formulas, 8-line type for the letters and 6-line type for the subscripts are suitable. If, after the ink has dried, the cards are brushed with plain duco their life will be increased. The cards then will not stick and they may be easily cleaned.



Name Card and Formula Card About 1/6 Normal Size.

CARD CONTENT

Each card set should include cards with the names of compounds and cards with the formulas of the same compounds. Above are samples from the oxide set which should be used near the completion of the oxygen unit and at times thereafter for

drill exercises. To the following sets can be added names and formulas if desired. The sets may not be as complete as some wish but they will provide sufficient material for drills in formula construction and in nomenclature.

I. The Oxide Set. Metallic Oxides: Names To Formula.

1. Aluminum oxide
2. Cuprous oxide
3. Nickelic oxide
4. Barium oxide
5. Lead monoxide
6. Hydrogen oxide
7. Ferric oxide
8. Strontium oxide
9. Antimony trioxide
10. Manganous oxide
11. Zinc oxide
12. Magnetic oxide of iron
13. Mercuric oxide
14. Calcium oxide
15. Cobaltic oxide
16. Lead dioxide
17. Magnesium oxide
18. Lithium oxide
19. Cupric oxide
20. Bismuth oxide
21. Stannous oxide
22. Arsenic pentoxide
23. Mercurous oxide
24. Cadmium oxide
25. Ferrous oxide
26. Sodium oxide

Metallic Oxides: Formulas To Names.

1. CuO
2. H_2O
3. Al_2O_3
4. Ni_2O_3
5. Fe_2O_3
6. BaO
7. Hg_2O
8. PbO
9. As_2O_5
10. SnO_2
11. CdO
12. MnO
13. Fe_3O_4
14. Li_2O
15. SrO
16. Co_2O_3
17. Bi_2O_3
18. PbO_2
19. SnO
20. CaO
21. ZnO
22. Cu_2O
23. MnO_2
24. Sb_2O_3
25. FeO
26. Na_2O

If desired, the nonmetallic oxide set can include the following oxides: CO, SiO_2, P_2O_3, SO_2, N_2O_3, P_2O_5, NO_2, CO_2, SO_3, N_2O_5.

II. Acid Set. Includes both name cards and formula cards. Only the name card set will be given here.

1. Nitric Acid
2. Permanganic acid
3. Sulfurous acid
4. Hydrobromic acid
5. Phosphoric acid
6. Sulfuric acid
7. Carbonic acid
8. Chloric acid
9. Nitrous acid
10. Boric acid
11. Acetic acid
12. Hydrochloric acid
13. Oxalic acid
14. Perchloric acid
15. Hydrosulfuric acid
16. Chromic acid
17. Chlorous acid
18. Tartaric acid
19. Arsenic acid
20. Hydroiodic acid
21. Hypochlorous acid
22. Phosphorous acid
23. Arsenious acid

III. Hydroxide Set. Includes both name cards and formula cards. Only the name card set will be given here.

1. Potassium hydroxide
2. Cupric hydroxide
3. Nickelic hydroxide
4. Barium hydroxide
5. Silver hydroxide
6. Calcium hydroxide

7. Bismuth hydroxide
8. Magnesium hydroxide
9. Mercurous hydroxide
10. Strontium hydroxide
11. Plumbous hydroxide
12. Sodium hydroxide
13. Chromic hydroxide
14. Zinc hydroxide
15. Auric hydroxide
16. Lithium hydroxide
17. Stannous hydroxide
18. Manganous hydroxide
19. Ferric hydroxide
20. Cobaltic hydroxide
21. Cuprous hydroxide
22. Stannic hydroxide
23. Cadmium hydroxide
24. Aurous hydroxide
25. Antimonous hydroxide
26. Nickelous hydroxide
27. Aluminum hydroxide
28. Ferrous hydroxide

IV. Salt Set. Limited to salts of HCl, H_2SO_4, $HC_2H_3O_2$, and HNO_3 used directly after the hydrogen unit. The positive radicals should be those used in the metallic oxides above. Both name cards and formula cards should be used.

V. Salt Set. Constructed from the acid set in II above and the positive radicals of the metallic oxide set in I above. Both name cards and formula cards should be used.

CARD MANIPULATION AND USAGE

Suppose the oxygen unit is near completion. The pupil will have experienced in the laboratory the preparation of a few oxides, possibly MgO, Fe_3O_4, SO_2 and P_2O_5. It is a convenient time after those preparations to begin teaching formula construction because the oxides afford positive radicals with a variety of valences and a simple negative radical. It is not so difficult at this time for the pupil to distinguish by names two oxides of the same positive radical by the use of the root word and suffixes. The flash cards can subsequently be used to test the achievement in formula construction and in nomenclature.

The instructor will flash the name set of the oxides before the class. The 4 inch by 11 inch size is convenient so as to allow the whole name set to be held in one hand. It has been mentioned that more cards can be included if desired. Referring to the name cards of the oxides in set I above, thirteen cards should be cut and be printed in order that the number one card will be aluminum oxide and the number thirteen card will be mercuric oxide. Number fourteen, calcium oxide, should be on the bottom of the number one card and finally sodium oxide, number twenty-six will be on the bottom of number thirteen, mercuric oxide. After card number one is flashed, it can be laid on the desk with the number one side up, the number two card on top of the one and finally number thirteen will be on the top. As the whole set is lifted, number fourteen will be on the top already to flash.

The contents of each set can be placed by formula in order on a single card for reference use for the instructor.

A few more things can be said about manipulation. That sufficient time has lapsed before showing the next card can be readily observed as the instructor faces the pupils. Before the cards are flashed and writing has begun, an announcement to the effect that no cards will be reflashed at the end will make the pupils more alert and will free the instructor from reshowing the whole set. A pupil will have no time to attempt cheating because he must watch the cards closely. Only a very few minutes will be required to flash the set. The papers can be quickly corrected in the manner suitable to the instructor who can rapidly observe the general mistakes in formula construction. After reteaching, another flashing will quickly reveal achievements. Subsequently, a check on nomenclature can be obtained by flashing the formula-to-name set.

It can be readily seen that the cards are useful for written tests but the cards are probably even more valuable for oral class drills. As the card is flashed and as the pupil reads aloud the name of the compound and then gives the formula or reads aloud the formula of the compound and then gives the name as the case may be, the pupils not reciting are inspired to make in their own minds the construction called for and can quickly rectify their mistake by comparison to the recited correct construction. That procedure can effectively assist the pupils in grasping nomenclature for it takes very little time during the flashing to explain or re-explain the use of such prefixes as *hydro*, *hypo*, *per*, *mon*, *di*, *tri*, *pent*, and such suffices as *ic*, *ous*, *ide*, *ite*, and *ate* while they are directly before the pupils.

The manipulation of the other card sets listed above under Card Content should be similar to the procedure in the use of the Oxide Set. The Acid Set, the Hydroxide Set and the Salt Set V can be used during the unit on acids, bases and salts. Occasional oral drills thereafter on any of the sets will be very helpful the first semester.

CARD USEFULNESS

1. More pupils are inspired sooner to memorize the necessary valences and radicals, especially if the instructor develops or uses intraclass and interclass emulation and instructive play or contest.

2. Pupils acquire more rapidly the significance of prefixes and suffixes in nomenclature. At the same time they become sooner

acclimated to a chemistry vocabulary through hearing the names pronounced by others as well as by themselves.

3. Effective drills can be given easily in a few minutes. Written drills can be given as often as desired in a short time for achievement tests. Test correction will not be burdensome.

REFERENCE

(1) Introducing Formulas and Equations to the Chemistry Beginner. By Francis C. Coulson, November 1931, SCHOOL SCIENCE AND MATHEMATICS.

THE UNITY OF ALGEBRA AND GEOMETRY*

BY LOUIS C. KARPINSKI
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In the past men supposedly expert in the teaching of Mathematics sometimes asserted that the opportunities for the interplay of geometry and algebra were rare. Of course the author of an old line algebra or the author of a geometry textbook inclined naturally to this belief as it conduced to the longer use of the given textbook. Notwithstanding any statements to the contrary many parts of algebra (one might well say "most parts") are illuminated by geometrical illustrations.

The simple product of two binomials is well shown as the rectangle upon the two lines of length respectively, $a+b$ and $c+d$, emphasizing graphically the four elements of the product. Particularly valuable illustrations are obtained by the special type $x+a$ by $x+b$, notably when accompanied by arithmetical illustrations, such as 47×43, 58×52, 69×61. Here a geometrical illustration makes it clear that three terms of the product have a common factor, useful in obtaining the numerical product. Thus $(x+a)(x+b)=x(x+a+b)+ab$ whence $47\times43=40\times50+21$ or 2021.

The expression a^2-b^2 represented as the difference of two geometrical squares is readily replaced by a rectangle with one side the difference, $a-b$, and the other side the sum, $a+b$.

The square of $(x+a)$ should be graphically given, and reinforced by abundant arithmetical application, particularly with fractions and decimals.

The binomial expansion of $(a+b)^3$ can readily be represented

* Address before the Mathematics Section of the Central Association of Science and Mathematics Teachers, Cleveland, November, 1932.

geometrically and is illuminating when considered in connection with $(a+b)$, and $(a+b)^2$ and extended to the fourth dimension, $(a+b)^4$.

Quadratic irrationalities, such as $\sqrt{2}$, $\sqrt{3}$, $\sqrt{5}$ and the more complicated $\sqrt{10-2\sqrt{5}}$ are easily represented geometrically employing the theorem that the perpendicular from any point on a circle to the diameter is a mean proportional between the segments of the diameter. This is one of the most widely useful of elementary geometry theorems. Naturally this topic connects with the graphical representation of complex numbers, the solution by quadratics of equations of the type $x^3-1=0$, $x^4-1=0$, $x^5-1=0$, $x^6-1=0$, $x^8-1=0$ and finally $x^{17}-1=0$, and the constructions with ruler and compasses of the regular polygons with the corresponding number of sides.

One simple geometrical construction of the real roots of the geometrical quadratic $x^2-ax+b=0$ is given by the intersections with the x axis of the circle on the line from $(0, 1)$ to (a, b) as a diameter. This is outlined in Dickson's Theory of Equations and numerous other constructions are known. Of course the Arabic geometrical illustrations of the equations

$$x^2+10x=39$$

$x^2+21=10x$ and $x^2=3x+4$ are classical.

These are given in the University of Michigan publication, *Robert of Chester's Latin Translation of the Algebra of Al-Khowarizmi*.

A simple illustration of the sum to infinity of a geometric series, with r less than 1, appears in the Karpinski, Calhoun and Benedict *Unified Mathematics*.

The terminology of algebra in cube and square and other terms indicates that algebra begins with geometrical considerations. The recent discovery in Babylon of the complete solution of numerical quadratic equations is of great interest in showing that in Babylon as in Egypt and Greece the algebraic problems arose from geometrical considerations. It should be evident that this unity appears not only in the analytical geometry but in countless other fundamental ways.

In 1920 the author published in this journal, Vol. XX, pp. 820–28, an essay on the parallel development of mathematical ideas, numerically and geometrically. The unity of the algebra and geometry is dwelt upon in that article, with particular references to the development of algebraic ideas geometrically in Euclid's Elements and interested readers are referred to that article.

A REPORT OF LONG PERIOD RETENTION OF THE SUBJECT MATTER OF SCIENCE COURSES

By Edith Bradley Wells
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Considerable interest has been evinced in recent years concerning the relative value, to pupils, of various teaching methods. Numerous pieces of research have treated such subjects as these: "The Project versus the Recitation-Text-book Method"; "The Contract versus Recitation-Book Method," and "Teacher Demonstration versus Pupil Laboratory Method." The latter problem especially has been the center of a great deal of investigation.

Part of the testing and discussion of the merits of these various methods has been concerned with the results of examinations taken by pupils immediately after the completion of the work of the course as compared with the results taken some weeks or months later.

When thinking about the question of retention of facts, it occurred to me that it might prove interesting to find out what kinds of facts are retained after a number of years, and by what method of instruction these facts were taught. In searching for possible sources of data, I remembered that my own mother had studied Biology and Physics some forty years ago in the East Side High School in Milwaukee, Wisconsin. Since graduation she has taken advanced courses in other subjects, but never again has studied science. Those facts about science which she can remember are, therefore, not mixed with a great variety of super-imposed facts and impressions.

At my request then, my mother wrote a brief statement of those activities and facts of the science courses which are still vivid after forty years. I am turning in her recollections, uncorrected, as I feel that any change might lesson the validity of the report.

I fully realize that the report of one individual is of little scientific value. Dr. E. R. Downing has been sufficiently interested in this individual statement, however, to suggest its publication. He hopes this reminiscence may stimulate other reports of "retention" of learning products of science courses taken some years ago. My mother's report follows:

"Forty busy years have passed since I studied Biology and Physics in the East Side High School in Milwaukee.

"Our Biology teacher was Professor George W. Peckam, a noted teacher and an authority on spiders. In a year's work with him in Botany and Zoology, I remember few recitation periods, by far the greater part of the time was spent in laboratory work under his enthusiastic and happy guidance.

"Well do I recall our study of the Amoeba, finding the cells under the microscope, their multiplying. Then the hydra, the movements of the tentacles, the taking in and ejecting of food. We noted in their simple structure that the entire body acted as digestive tract.

"We dissected clams, crayfish, and lobsters,—and saw for ourselves the evolution from the simple to the more complex,—we saw tissues and organs vary in structure and form, as they performed specific functions.

"I'll never forget the nervous system of the clam; the darker more tenacious tissue embedded in the lighter substance of the body. Simple though the entire system was, it took careful, patient, steady following up with the knife to keep it unbroken and intact, without a break. The entire nervous system opened up, showing the little enlargements, gave us some inkling of nerve ganglia. We could see clearly how stimulae were carried. We found the clam's ear in his foot.

"Two students at one table, had one lobster to work with. With our teacher's help, we saw the heart beat,—it was with wonder we watched it.

"In Botany, we studied some plants,—the one I remember most distinctly was the bean plant. We watched the development of the cotyledons, the two leaves that formed. With this plant as basis, we studied other plants and flowers.

"Our note books were not expected to be works of art, but they must show the parts, their functions, and their relation to each other.

"In a later course in Physiology with this same teacher, we studied a drop of our own blood under the microscope. We saw the relative number of red and white corpuscles, and learned something of the properties of the serum of the blood.

"In Physics, under Professor Rogers, the experiments were performed by one or more members of the class, and here I also remember those I performed myself and demonstrated to the class.

"The experiments in which I showed the process of osmosis, the principle of siphonage, the results of the application of force; these are more distinct in my mind than those which I saw others perform and did not handle and work myself.

"One experiment I saw two boys perform, I always wanted to work out practically myself, that was the lift pump. The boys explained the cylinder, the piston, the valves, the vacuum, the suction. I saw the pictures, and passed an examination on its workings, but I never have felt that I comprehended the operation. Later on, we had a wheezy pump in the kitchen in a country place. I sent for repair men and thought that at last I was going to see the parts and understand the phenomenon. But no such good fortune was mine. When the men came, and I humbly asked to see how the thing worked, the attitude of the men told me plainly that that was not a woman's sphere."—*Cora Taylor Bradley.*

THE LABORATORY

By The Physics Department
West Technical High School, Cleveland, Ohio

[The general directions for correct use of the laboratory and for laboratory study given here were presented before the Physics Section of the Central Association of Science and Mathematics Teachers at Cleveland, November 1932. Individual laboratory instruction is frequently criticized and is now on the defensive because time is frequently wasted, expensive apparatus is broken by careless usage, and the method used often results in mere busy work of copying results and filling blanks with meaningless words, figures and symbols. Teachers must correct such conditions or submit to demanded changes. An outline of this type with frequent reference to it and insistence that its recommendations be followed will improve results.—Ed.]

I. *Its purpose.*

1. "Laboratory" means "a place to *work*." It is also a place of opportunity.
2. This laboratory gives you a chance to test for yourself many of the principles and laws of Science, thus getting a better idea of their real meaning and possible uses than you could obtain by merely reading about them in your text book.
3. Here you will have an opportunity to learn the methods used in the scientific experimentation which has led to so many of our great modern inventions.
4. You will be allowed to use beautiful and accurate measuring instruments some of them the same as used in the great research laboratories. You will have a chance to find out how they are constructed and operate, and to learn to use them.
5. Conscientious work in performing experiments and making out reports of them will help you to develop habits of careful observation, accurate measurement, and orderly arrangement of the information you acquire.
6. Most valuable of all you may learn to estimate fairly the relative importance of different items of your information, judge accurately their relation to each other, and finally to reason out honest and logical conclusions.
7. You know that all the things just mentioned are necessary in engineering or technical work of most kinds, but possibly you do not realize that they are almost equally

important in other professions or in business. The progressive lawyer, doctor, merchant, farmer and minister must carry on investigations and experiments, and his success in his profession or business will rest very largely on his ability to do this and to reach sound and logical conclusions as a result.

8. Then, too, your training here may have a still broader and more valuable use. You are already a citizen. You already have some influence because your education is even now above the average. In three or four years it will be your duty to use your vote as well as your influence in favor of good government and sound social and economic conditions. Why not try the scientific method in these matters?
9. But don't forget, "a place to work." The laboratory bears much the same relation to your class room work and text book that the football practice field does to the coaches' lectures and the rule book. You never "make the team" by loafing at practice.

II. *Equipment and Its Use.*

1. The tools and materials that you are required to furnish are few and inexpensive but should always be at hand and in good condition. You will provide:

   No. 1 Black Pencil for writing
   No. 3 Black Pencil for tracing and drawing
   15 cm. scale
   Protractor
   Pencil Compass
   Theme Paper
   5 Report Covers
   1 Brain—your own

2. Your parents and other taxpayers have provided the hundreds of dollars worth of other equipment that you will need and are loaning it to you. You can show your appreciation by handling it carefully and leaving it in the best possible condition. The following precautions will help:

   a. Keep hands off all apparatus until instructed in its use.
   b. Use carefully and only as instructed.
   c. Place any such delicate and expensive instrument as a voltmeter or galvanometer *on the table* and let the other fellow pick it up. These instruments are as easily injured as a fine watch and cost more to repair.

d. As soon as your receive an instrument examine it for any apparent damage. If any is found or develops later report at once to the instructor. When in doubt as to adjustments consult the instructor. Do not try to force tight screws or joints.
e. Always study the capacity of an instrument before putting a load on it and be careful not to overload it. Study scale values *before* applying a load, and be ready to take prompt readings.
f. Always record identifying number of instruments used.
g. Whenever possible, carry out computations and check results before taking down apparatus.
h. When through with apparatus take down carefully and completely, and put where found unless otherwise directed. Be especially careful not to leave pieces of wire attached to electrical apparatus.
i. It is just as bad taste and just as crooked to deface school equipment by cutting or scribbling on it as it is to do these things to the furniture and walls of your friend's home.

3. Do not let these warnings make you afraid to take the responsibility of handling instruments. Here is your chance to make friends with them, and you are cheating yourself if you pass it up. If you sit back and let George do it, it will be George that we recommend for that job at the Electric Illuminating, Bell Telephone, or General Electric.
4. Now about that brain. Keep it working a bit ahead of your hands every minute. Don't twist screws or close switches till you have a reason for it.

III. *Readings, Calculations,* etc.

1. *Readings*

Try to decide for yourself what accuracy of reading is worth while for any instrument and for any particular measurement. You can read your metric scale to less than a mm. Is it worth while to do so when finding the area of the table top? When finding area of a circle between 6 and 7 mm. in diameter? Is it worth while to worry over whether a voltmeter of 1% accuracy is reading 110 or 110.1 volts?

However, do not get careless and satisfied with "about" readings. Always read as closely as the accuracy of the instruments and the conditions of measurement will justify.

2. *Calculations*

In general you will carry results to three significant

figures as: 247, 2.47, .247. You may use $\pi = 3.14$, $\pi/4 = .785$.

This holds for text book and test problems also.

3. *Trials and Averages*

In many cases difficulty in making exact readings makes it necessary to take several readings, usually five or more, and average these for your final value. In other experiments you may average the results of several trials made under varying conditions. You must use judgment in this work, however. Examine the following sets of readings, all taken from the same source, and discuss their validity for averaging.

(*a*)	(*b*)	(*c*)
2.43	2.45	2.47
2.44	2.44	2.44
2.56	2.43	2.51
2.42	2.44	2.39
2.44	2.42	2.52

4. In all your work use your general knowledge and common sense. There is no rule against using information you have gained in math, shop, drawing, English, athletics or entirely outside the school in your science work. Neither is there any rule against using what you learn in school after you leave it.
5. Rough-check your work to see if it is reasonable. Why turn in a report that gives the tensile strength of aluminum or copper as two or three times that of steel? Look out for a skidding "decimal point." If you have multiplied by .24 should your result be over twice the original number or about one fourth of it?
6. Science is absolutely *honest*. Its conclusions are utterly worthless unless based upon truth and reached by unprejudiced and honest reasoning. The true scientist scorns any effort to make his work look better than it is, or to claim the slightest credit due another.

IV. *Reports*

1. The written report of an experiment should include:
   a. Number and title
   b. Purpose or aim of the experiment
   c. Theory, explaining the principles involved in the experiment
   d. Method, telling briefly what was done
   e. Data or facts obtained, usually tabulated
   f. Discussion and conclusion.

2. The ability to write a good report is one of the most valuable things you can take from school with you, even if you do not follow technical pursuits. Foremen and managers must make reports. The lawyer's report is a brief, the minister's a sermon, the judge's a decision. The success of these men depends largely upon their ability to produce strong convincing reports.
3. The best time to write your report is immediately after the experiment is finished. The details are then fresh in mind and your interest still strong and undivided.

A SIMPLIFIED FREE FALL APPARATUS USING 60-CYCLE A. C. AS TIMER

By J. M. Arthur, *St. Mark's School, Southborough, Massachusetts*

The apparatus illustrated was suggested by Prof. Bowie's article in the Nov. issue of School Science and Mathematics. Its advantages lie in the fact that no magnet nor coil is required, metallic trap doors making and breaking the circuits as necessary.

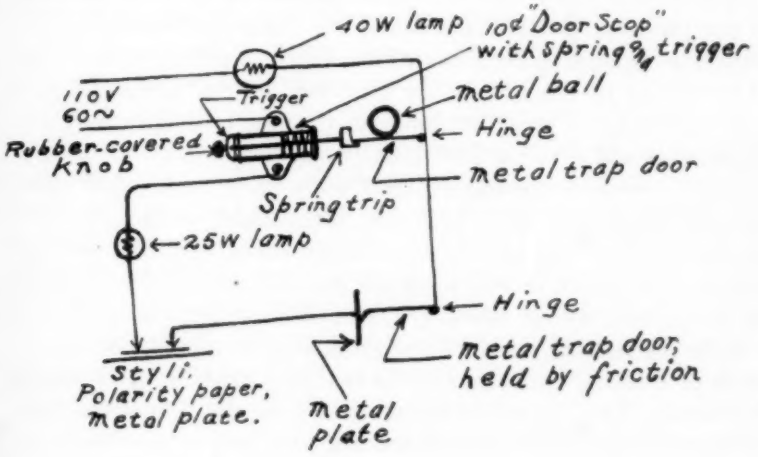


Diagram of Circuits for "g by Free Fall.

As to its simplicity of operation;—Ten boys working in pairs mastered its technique so readily that ten satisfactory readings were obtained in less than half an hour. The average value for g was 98.33 cm. and 32.20 ft. as against 980.3 cm. and 32.16 ft. as "accepted values" for Boston.

The actual cost of the completed machine need not exceed $1.00. Even the lamp in the stylus circuit might be dispensed with, as is obvious from a study of the circuits. A single, small-wattage lamp in the overhead position could supply the necessary resistance for the circuits.

TEACHING BIOLOGY THROUGH THE STUDY OF DISEASES[1]

By Harold B. Robertson
University of Southern California, Los Angeles

It was suggested to the writer that it would not only be possible but highly desirable to teach biology to secondary school pupils through a preliminary study of selected diseases. It was assumed that pathological conditions would be used primarily as an *approach to* rather than as a *substitute for* the usual course content. In investigating the possibilities of such a system of instruction the method of procedure followed was that of job analysis as described by Dr. Claude C. Crawford in his book, *The Technique of Research in Education*.[2] Nine major difficulties accompanying the use of this method were formulated and investigated. The remainder of this paper gives the practical solutions that were discovered for meeting these nine difficulties.

How to justify this approach to the subject. Because the novelty of the proposed method provoked the usual suspicion and distrust accompanying all innovations, the first difficulty was that of justifying its use. There are however, several advantages of such a system for teaching biology. (1) The large group of students who will take no additional work beyond the first introductory course are made familiar with these facts concerning disease which will later prove of inestimable value. (2) The method also favors the orientation or survey type of biology course, and hence is well adapted for students who will enroll for advanced biology work. (3) A further advantage would accrue in instructing such special groups as premedical students, adult or mature students, and for teaching physiology to nurses in training. (4) The use of the method provides a new and nonstereotyped approach; it is based upon the sound psychology of arousing student interest and then permitting the class to follow the line of its interests while studying the requisite work as outlined in the syllabus. (5) Conducting the course in this manner provides a flexible course easily adaptable to local happen-

[1] Biol. Editor's note:—It is the opinion of the Biology Editor that this type of course can not take the place of a good course in biology which emphasizes a grounding in principles. The paper is well written and suggestive for any course in general biology. The teacher who administers a course of this type would have to be a rare individual in preparation and experience. With the inexperienced or poorly trained teacher such a course is out of the question. In any event the course should be presented only to advanced students who have had a thorough grounding in the principles of general biology. As an advanced course in the later years of the high school or in the junior college the editor sees in it wonderful possibilities in the hands of the superior teacher.

[2] Claude C. Crawford, *The Technique of Research in Education*. University of Southern California, Los Angeles, 1928, pp. 143–147.

ings of prominence. (6) In addition to making the subject more personal to the students, this method would emphasize the practical features of the course. (7) Biology taught through such an approach would stress the scientific method of thought, stimulate the students vocationally, and provide for individual differences.

The teacher would also be benefited. (1) In order properly to conduct a course by this method the teacher would need to increase his fund of information. This in turn should result in professional growth. (2) Better lesson plans would be a requisite, as well as increased skill in laboratory technique. Still other advantages are, (3) emphasis on the social aspects of biology, (4) the prominence given to good health and obedience to natural health laws, and (5) the impression of the students with the economic cost of disease.

As in the case of every method, there are accompanying disadvantages. Those most frequently mentioned were: (1) The elaborate physical equipment needed, (2) the inability to find a text written for use with this methodology, and (3) the fact that the method might demand more in the way of teacher preparation and instructional skill than the results would justify.

How to prepare oneself to teach the subject in this manner. The teacher who has decided to adopt this methodology can prepare himself in many ways. (1) He may enroll for a summer session in a university, taking such courses as bacteriology, plant pathology, entomology, pathology, and others of similar character. (2) Or he may visit institutions which deal with certain phases of biological subjects which would be of interest from the pathological viewpoint. He may, for instance, visit hospitals, public health departments, veterinarians, abattoirs, museums, county agricultural agents, the forestry service, and others of similar character. (3) There are still other sources of information available to the ambitious teacher, as, for instance, literature which may be consulted with profit. Examples of this kind include such sources as standard textbooks, scientific journals, bibliographies, bulletins of various state and federal bureaus, and trade magazines. Still other sources of valuable information are the school physician, breeders and fanciers of stock, and non-profit societies incorporated to promote special objects.

How to choose the particular diseases to study. After one has prepared himself to teach biology through the study of diseases, he is faced with the difficulty of selecting some particular dis-

eases as a basis for class study. In planning the course the teacher should judge the diseases which seem particularly suited for his purpose by a number of criteria. Among these may be mentioned: (1) Consideration of the limitations of the physical equipment of the school. Diseases should not be selected whose study requires better equipment than the school provides. (2) The needs and viewpoint of the students. (3) The range of natural objects available. In a large city the teacher will find it more difficult to obtain certain specimens than will his neighbor in a small village. (4) Diseases should be selected in accordance with their relation to fundamental biological laws by selection of such conditions as will best illustrate the desired objectives. (5) Diseases selected should be locally prevalent, non-repulsive in character, and should be those whose onset is followed by the most serious consequences. (6) The selection should include those which may be avoided by proper precautions on the student's part, thus emphasizing personal hygiene. Civic biology will be stressed if diseases which are socially important are included in the course of study. (7) The economic cost of disease can be taught by selecting diseases which are themselves economically important. (8) The age level of the class should also be considered. (9) Diseases which have prominent symptoms should be included because of the youth and inexperience of the learners. (10) It is also well to include diseases which are being prominently featured in the press at the time, in order to sustain pupil interest and demonstrate the practical features of the course.

How to choose the order in which to study the diseases. After the particular pathological conditions for class study have been selected, the teacher is then faced with the problem of selecting the order in which the diseases should be considered. (1) The course of study is perhaps the most important determining factor in this respect. Lesson plans should be made which fulfill curriculum requirements and the diseases "fitted into" these. (2) Early pathological studies should be devoted to the plant kingdom in order to prevent too personal application until the students have acquired a sufficient background of biological information. (3) Other things being equal, diseases should be selected for study in the same order as they are mentioned in the text. (4) Diseases with inciting agents of relatively large size should be studied before those which are less easily visible. (5) In selecting the order of study, the instructor should consider

the factor of seasonableness. Thus colds should be considered in the winter and hay fever in the fall. (6) In conducting the course, the teacher will no doubt proceed from the familiar to the less well known and hence will select diseases in accordance with their prevalence. (7) Diseases should also be considered from the viewpoint of ease of control.

How to get classroom aids from outside sources. When using this approach, the obtaining of classroom aids, while it presents some difficulties, is not a serious problem. (1) Teaching aids may be obtained from makers of school supplies. (2) If the school budget will not permit this, the teacher must use his ingenuity in utilizing available objects. (3) Stereopticon slides and cinema films may also be rented. (4) Public officers may be induced to deliver addresses and in so doing become teacher aids. (5) Hospitals and medical schools form other sources of aids, while the Board of Health has in its files much information of a valuable nature. (6) Packing plants and animal hospitals are also good sources of specimens which may prove useful. (7) Other teaching aids may be obtained from scientific journals, from governmental bureaus, and from other non-profit organizations. (8) Then too, many of the pharmaceutical companies issue pamphlets descriptive of their products, which may contain much valuable information.

How to connect the classroom work with experience outside of the classroom. In the attempt to make class work more real and more practical, this factor is receiving an ever-increasing attention from every up-to-date teacher. (1) Reference material should be close to the age level of the child in order to be most effective and should of course emphasize the desired objectives. (2) Illustrations used should emphasize prevention of disease. These may include reference to required collateral reading in order to increase interest in this phase of the work. (3) The references should be to subjects of particular interest to adolescents such as athletics, vacations, and others of similar character. (4) A connection can often be made through the universal desire for good health. (5) In this connection it is possible to refer to the illness of a class member. (6) Vocational possibilities may also be used to connect the class work with outside experiences. (7) Occasions which affect the entire school, such as vaccinations, make good contacts with the out-of-school world. (8) If the class work can be related to commerce and economics the subject should be made more real thereby. (9) A reference con-

necting the school work with current advertising is always a valuable one to make.

How to teach the appreciation of the work of famous investigators. The historical approach to the study of biology renders the proposed plan of teaching less difficult than when the subject is taught by the more usual methods. Some of the things which may be done to increase appreciation are: (1) Have the class visit selected industries which utilize a process which has been studied in the classroom. (2) Motion picture films of various industries are also valuable. (3) Projects by the students and required collateral reading to stimulate appreciation have long been used for this purpose. (4) Dramatic sketches written and presented by the class and dealing with incidents in the lives of famous biologists have also been used to increase appreciation. (5) Some teachers use the first meeting of the class for an appreciation lesson. (6) Many favor the use of "salesmanship" to promote appreciation but admit that the appreciation lesson is most effective when its use appears spontaneous. (7) The use of anecdote is a favored method of teaching appreciation while some use as illustrations of worthy investigators, those scientists who are still alive. (8) Some appeal to patriotism, some to practical economic considerations and others to the idealism of youth.

How to prevent the course from becoming a morbid study of the abnormal. Although it might be assumed that the use of this method tends to make the course morbid in content, this should not be the case for there are many devices which may be used to prevent such an undesirable occurrence. (1) The teacher should himself cultivate a cheerful optimistic disposition. (2) He should encourage the class to indulge in all healthful activities. (3) The instructor should utilize the minimum number of non-repulsive diseases. These as well as all illustrative material should be selected with great care. (4) Emphasis upon the purely pathological should be strongest on the lower forms of life. (5) After having observed the abnormal, the teacher should always stress the normal and so provide an antidote for morbid thoughts. (6) The instructor should emphasize the optimism which pervades science. (7) He should devote the major attention to emphasizing health and disease-prevention rather than the pathological condition itself. (8) The teacher may show why he feels optimistic over the subjects of disease by pointing out such things as increasing longevity in man and the development

of disease resistant species in lower organisms. (9) He may refer to the minor percentage who succumb to diseases and show the many devices which are available to combat disease. (10) He may emphasize the fact that few bacteria are pathogenic, that one is endowed by nature with adequate powers of resistance and that through serum therapy this resistance may be considerably increased.

How to preserve the unity of the course. In teaching biology through this method, the instructor must use care to preserve the unity of the work. In attempting to preserve such unity there are several devices which are available. (1) The instructor should outline the course in considerable detail before the beginning of the term and should also continually make reference to facts previously learned. (2) The teacher should also select several central ideas and use them as unifying devices, as dominant themes which, running through the course, serve to bind all into a unified whole. (3) Among such unifying ideas might be mentioned good health and the active fight against disease. (4) Other unifying devices of the same general character are economic aspects of biology, the historical background of biological discoveries, environment and the structure of the various organisms.

A DISPLAY OF TEXTBOOKS

Among the educational features which are to be offered at the Century of Progress Exposition in Chicago this summer are several contributions by Ginn and Company which should be of unusual interest to school people. The first of these will be a comprehensive display of textbooks in use since 1833. Interesting specimens of early nineteenth century and of late nineteenth century books will lead progressively to the books of today. The early specimens on exhibition will come from the collection of Mr. George A. Plimpton of New York, a member of the firm of Ginn and Company, whose library of famous textbooks is the most extensive in the world. Few realize that there was little progress in textbook making from the early colonial period up to 1833. The most illustrious book of this early period was the New England Primer which we look upon as a crude educational effort, but which continued in use in schools even later than 1833. The exhibit thus covers much of the history of textbook making in this country and should prove illuminating to every student of the history of American education.

Another unique feature consists of two miniature models of schools—one a dame school of early New England, the other an early colonial one-room rural school. Two architects and a sculptress have been busy at work on the interiors of the rooms, the furniture, and the figures of pupils and teachers. Architectural details, costumes, coloring, and all appurtenances of the early schoolrooms were determined by long research and will be represented as accurately as possible in the small models.

NATURE STUDY AND ELEMENTARY SCIENCE IN THE ORIENT

By Anna Clark Jones
Madison, Wisconsin

The writer had long wished to see how education, and particularly nature study and elementary science, were progressing in the Orient. The opportunity came in 1931 and 1932 during a journey through Japan and China. Some fifty schools and colleges were visited including kindergartens, primary and secondary schools, colleges and universities. They were scattered along the route of travel from the north of Japan to the south of China.

In each of these countries education has been reorganized along western lines. Japan shows the most progress in this direction having completely replaced her old schools with a modern system. This comprises elementary schools attended by 95 per cent of the children, and a large number of high and technical schools, colleges, and universities.

The elementary schools were by far the most interesting, at least to the writer. Their neat wood or brick buildings, usually surrounded by ample grounds are to be seen in every village and city. The rooms are furnished much as in America with seats and desks, a blackboard, and a limited number of reference books. The curriculum of these schools shows the familiar studies, native language, history, mathematics, nature study, art, etc., but the content of them reveals the conflicting ideals of eastern and western cultures. Science is, perhaps, the one universal subject. Nature study of the biological type is carried on in the lower grades merging into a kind of general science in the fourth grade. For work of this kind special rooms are sometimes provided. In some rooms there were low tables about a yard square accommodating four or five children. The instruction, often conducted by teachers especially assigned to this work, carried on the lessons according to methods familiar in America. Specimens were placed upon the tables and the children observed, sketched and wrote in their notebooks. Upon one occasion the eggplant, tomato, and cucumber were being studied. The teacher said, "Your gardens are not large enough to raise these vegetables so we will study them." Observation was followed by a spirited discussion upon the forms, varieties, culture, and cooking of these vegetables. A lesson on the snake was

taught by the observation of preserved specimens, with no apparent attempt to secure living material. In another instance a lesson on the barometer was given to the fourth grade, in which the teacher performed the Torricelli experiment. Another teacher gave a lesson on the thermometer by passing a number of thermometers around the class, discussing the principle of the thermometer and sketching three types of thermometers on the board. On the whole the work observed was substantial in character but formal and lacking in the dynamic element found in the best American schools. It also seemed noteworthy that little attention was given to the esthetic element.

The higher primary and middle schools visited were well equipped for teaching general science. Physical apparatus was usually stored in a large light room adjoining a lecture-demonstration room. Class rooms often contained a collection of pictures of the great scientists among which those of Noguchi and Thomas Edison were always to be found. One school in Korea had a laboratory furnished with tables of the Caldwell type.

Excellent school museums have been developed in some places. They were usually located in large light rooms and contained collections of plants, animals, rocks of the vicinity, and exhibits of local industries. A school in Fukuoka, southern Japan, had developed also a well equipped geography museum containing maps, charts, and very fine relief maps made by the students.

Some work is done in school gardening. In one instance vegetable gardening was emphasized, in another the culture of tropical fruits. Upon the grounds of another school in which an ancient temple was located, the children had developed an ornamental garden. Making of miniature gardens which is sometimes used as a nature-study exercise in America seemed to be treated as a domestic art in Japan and was taught, as was flower arrangement, in connection with Japanese etiquette.

In general, nature study and elementary science appeared to have an established place in the elementary schools of Japan. Science in the higher schools and universities is highly developed under faculties trained in the best schools of the world.

The nature study and elementary science instruction given in the schools by no means represents the whole of the child's contact with work of this kind. Japan is an agricultural nation and children as well as adults engage in the family occupations. Long experience has made the Japanese expert farmers, gar-

deners, and sericulturists. They are also aided by the latest scientific information furnished them by the government and often by farm or agricultural experts employed by villages to give instruction to each family.

Appreciation of beauty in nature is so inherent an element in Japanese culture that it perhaps needs less attention in formalized nature study than in western schools. The finest work of the landscape artists accompanies temple and palace architecture while within in accordance with decoration of wall or screen may be found the "maple-leaf room" or the "pine-tree room." The artistic temperament of the Japanese has, through contact with their natural environment, been attuned to the charms of mist, rain, and snow, of cherry blossoms and autumn leaves, of moss and sand and lichen to a degree seldom seen in occidental countries.

In China, opportunities for visiting schools were less favorable than in Japan, still some clear impressions were gained of what China is trying to do educationally as well as the limitations under which educational leaders are working.

Since the revolution China has been attempting to introduce a modern system of democratic education but as yet only from 2 to 15 per cent of the children are in attendance. According to figures furnished by the physicians in charge of public health in Peiping, the city had (1930) 66 public elementary schools with an enrollment of some 15,186 pupils, and 2,135 pupils in secondary schools. These are of course very small numbers for a city of nearly one million people. Relatively more progress has been made in developing colleges and universities. Naturally those institutions engaged in training leaders must precede any large developments in the lower schools. Peiping, the educational and cultural center of China for centuries, has four or five colleges including the Normal University in which one thousand young men and women are being trained for teaching.

Conditions in the elementary schools seem to vary much and changes are continually in progress. A glance at Public School No. 7, Peiping, will perhaps give the setting of a city school. It is housed in a group of one-story buildings surrounded by a wall. Walking through a long corridor on the front of the buildings room after room is passed. All of the rooms have stone floors and are very simply furnished. One sixth grade class room was equipped as follows: old-fashioned wooden benches for 40 or 50 children, a blackboard, a chart showing the attendance record,

a map of China, a map of Peiping, a feather duster and mottoes. The teachers' room contained newspapers, maps, and some science apparatus. Another room in charge of the Self Control Society was headquarters for children's clubs, athletics, etc. Chinese schools are apt to have a small ornamental garden consisting of a number of potted plants and large bowls of goldfish. A small school in Canton was housed in the remains of an ancient temple. All about were strewn fragments of fine architecture. In fact, one may expect to find Chinese schools in almost any kind of a building.

The course of study was interpreted to me by the teachers as including natural science for all grades covering the study of birds, flowers, metals, and a little chemistry and physics. But although assured that such study was in the curriculum, little science or nature study was seen in the Chinese schools visited. Language difficulties are so great in China as apparently to limit other kinds of instruction. The nature study actually observed seemed to consist of copying from charts, or with the older children, classifying plants or animals, dissecting animals, or learning taxidermy. The work was reminiscent of what went on in the United States some forty years ago. The elementary readers, as their content was interpreted to me, contained some scientific material about plants, animals, the rain, etc.

The village schools are usually housed in old private dwellings as very few new buildings have recently been erected in China. A small agricultural village near Nanking was using a house consisting of three one-story buildings surrounded by a wall. Two of the buildings were used as school rooms, the third as a home for the two teachers. The nature study equipment was apparently limited to a number of potted plants, several swarms of bees, and a few health charts. It was significant of the spirit in modern China that the village farmers who had secured these buildings primarily for the schooling of their children, made use of them in the evening for lectures or discussions in agriculture.

The task of establishing democratic public education in China is very great as there is need not only for many teachers, but the basic content of the several studies is as yet not even approximately determined. It is, therefore, not surprising that nature-study and elementary science are but little developed. Some beginnings, however, have been made in the elementary school. Systematic instruction is also generally found in the higher schools, and in such colleges as Yengching, Nanking, and Ling-

nan strong work in science is being done. From these latter institutions well trained young people are going out prepared to do their part in building up science in China.

The Orient was left, therefore, with the feeling of encouragement over the progress of nature study and elementary science in spite of great difficulties. Japan has not only gone far in adapting western culture to her own needs, but has greatly influenced Korea and China also. Before the outbreak of present hostilities it was stated that China had more students in Japan than all other foreign countries combined.

The influences of scientific thought, beginning with nature study and elementary science were thus found to have completed their march around the world. Wideawake native teachers, well aware of what was going on elsewhere, were devoting themselves to their tasks. The enlightenment of science must surely be one of the most potent factors in solving the problems of the Orient.

SQUARING THE CIRCLE FOREVER IMPOSSIBLE

Squaring the circle, that is, constructing a square exactly equal in area to a given circle with no other instruments save straight-edge and compass, is one of the "impossibles" of mathematics. So said Prof. Edward Kasner of Columbia University, in a radio talk given under the auspices of Scienec Service, over the network of the Columbia Broadcasting System.

"The Squaring of a circle, in the way in which the problem is to be understood, is absolutely impossible," he said. "It has never been done and it never will be done."

Circle-squaring was one of the favorite undertakings of learned men in all times, ancient, medieval and modern. Its very difficulty and believed impossibility served only as a greater lure. Close approximations could be made and have been made, but exact equivalents have never been achieved with the tools of classic geometry.

Until 1882 would-be circle-squarers had at least a moral right to keep on with their endeavors, Prof. Kasner explained, because nobody had ever brought forth conclusive mathematical proof that the feat could not be accomplished. But in that year a German mathematician named Lindemann formulated an involved but complete demonstration that the long-sought solution could never be found.

Similar proofs have been found that two other classic geometrical riddles can never be solved. These are doubling the cube and trisecting the angle. Doubling the cube, that is, constructing a cube of exactly twice the volume of an original model, cannot be done because the solution depends on finding the square root of 2, which is impossible to determine exactly. Some special angles can be trisected with ruler and compass, like an angle of 90 degrees, but no method of trisection good for all angles can ever be found.

Persons who continue to seek for these mathematical impossibilities, Prof. Kasner indicated, are wasting their time and are not entitled to the serious attention of mathematicians.—*Science Service.*

A MATHEMATICAL FANTASY

By Elizabeth B. Cowley
Pittsburgh, Pennsylvania

Place: The living room of the Jones home.
Time: 4:30 Wednesday afternoon, November 9, 1932.
At the right Ray is seated at a desk studying; Mrs. Jones sewing at left.

Ray. (*Suddenly looking up*) I am tired of studying. Why does a teacher ask a class to write essays about high school studies? They have no value. I know that the world would get along just as well without history and chemistry; and I would like to live in a world where there is no mathematics. (*Yawning*) I am too tired to do anything but sleep and dream. (*Puts his head down on the desk*)

Lights go off and then come on again at once. There is a loud noise outside and a rapping at the door. Mrs. Jones opens the door.

Town Crier. (*Enters ringing a bell, swinging a lantern, and unrolling a scroll*) Hear ye, hear ye, hear ye! All forms and kinds of mathematics are banished now and for all time to come. Anyone found using any mathematics shall be beheaded. All clocks, calendars, money, and other devices using numbers are to be confiscated.

Men enter carrying a large basket into which they throw the clock, the calendar, etc., and then follow the town crier as he leaves the room.

Mrs. Jones. (*Sinking into a chair*) What does all this mean? I shall telephone to Mr. Jones and ask him. (*She takes down the receiver*) But I cannot telephone, for the numbers have all been taken from the dial.

Michael. (*Bursting into the room shouting*) Oh, Mother, this is great. No school for a long time. The teachers must destroy all textbooks in arithmetic, algebra, geometry, trigonometry, and bookkeeping; and take the dates and other numbers out of history, geography, physics, and chemistry; and the page and chapter numbers from all—

Frank. (*Rushing in carrying a football suit*) Here, stop that, will you? This is no fun for me. We cannot play football, for there are no numbers for signals; and all schedules are cancelled.

Francis. (*Enters hurriedly*) Someone come and help me find my car. All license plates have been destroyed. I started to unlock a car I thought was mine, but a fellow knocked me down and said it was his.

EUGENE. (*Enters ringing his hands*) How shall I finish building my airplane? All my measuring implements are gone.

MORRIS. (*Enters panting*) Well, here I am. Am I late for the party? I had to walk all the way from the East End to the North Side. There are no street cars or taxicabs, because they need numbers.

ARTHUR. (*Enters carrying a bundle*) Oh, I tried on almost every pair of boy's shoes in the store before I could get a pair to fit me. There are no sizes now. The worst of it was that there is no money, and I had to give the clerk my fountain pen, my muffler, and my mackintosh.

PHYLLIS. (*Enters crying*) Oh, please help me to find my home. We moved yesterday to a red brick house with white curtains. It was 2345 Fifth—

CHORUS. (*Shouting*) Hush, you will be beheaded for mentioning those numbers.

LAIRD. (*Enters drumming with his fingers*) I can never play the piano again for there are numbers in the scores.

GUY. (*Following Laird*) Oh, we shall never know who was elected President for no one dares to count the ballots.

MR. JONES. (*Entering wearily*) Our firm has gone out of business. No more engineering work can be done. That big office building and that bridge will never be finished. I do not know how we are to live. Luckily my name was painted on the car, and there was plenty of gas in the tank. I shall drive out to Jim's farm. Perhaps he needs a farm hand and will pay me in eggs, chickens, and vegetables.

HOWARD. (*Enters whistling*) Say, Mother, isn't it dinner time? Oh, where is the clock? I am hungry. Lets have a good dinner.

MRS. JONES. We cannot cook until we get some coal and a coal stove. The gas is turned off because the meter is gone. It had numbers. We have some bread and butter and a few cold boiled potatoes left from yesterday.

ALL TOGETHER. Cold boiled potatoes!

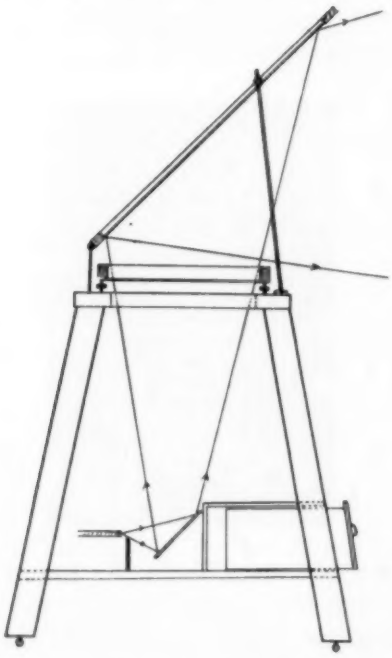
The lights go off for a minute. When the lights come on, the clock is in its place and all have left except Ray.

RAY. (*Raising his head and stretching his arms*) Why, the clock *is* there. It is five o'clock. I must get to work at once and write that essay about the value of Mathematics in our daily life. Wow, that was a terrible dream I had. Oh, how good that supper smells!

THE RIPPLE TANK AND THE DOPPLER EFFECT

By Hiram W. Edwards
University of California at Los Angeles

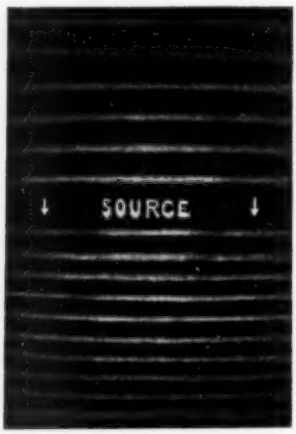
The ripple tank is a particularly useful piece of apparatus for demonstrating many of the fundamental principles of optics from the standpoint of the wave theory. In fact its use in demonstrating the phenomena of reflection and refraction of plane and spherical waves from plane and spherical surfaces, of



interference, of Huyghen's theory and of many other important principles, makes the ripple tank an indispensable piece of equipment for the physics lecture room. Because of the value which the writer attaches to this apparatus, he has designed and constructed a table which serves as a convenient mount for the source of light, the mirrors, the tank and the auxiliaries, and makes it, therefore, immediately available. An improvement has been made in the construction of the tank itself which eliminates disturbing reflections from the sides of the tank. An extension of the usefulness of the equipment has been accomplished by

mounting the vibrator on a movable frame, thus making it possible to illustrate the Doppler effect.

A diagram of the complete assembly is shown in the accompanying illustration. It will be noticed that the arc lamp is placed in the lower framework of the table and that drawers are provided as depositories for the numerous small parts of apparatus. The two mirrors make possible the projection upon a vertical screen or wall. The angle of inclination of the large mirror is adjustable. An opaque shield (not shown) is placed so that extraneous light from the lamp is eliminated from the screen. In operation, prompt adjustment is secured by leveling the tank and pouring into it a measured quantity of water which has been found to give the best results.



In order to prevent disturbing reflections which are caused by the vertical sides of the tank, it was found desirable to provide an absorbing device. This was accomplished by introducing a sloping "beach" on all four sides of the tank. The beach was made of soft wax pressed into place and was about 4 cm wide. The edge of water extended about half way up the beach. It was found that waves were not appreciably reflected from such a shore.

The need of a good device to illustrate the effect of a moving source upon the wave length of the emitted radiation was filled by mounting the vibrator, which is used to provide plane waves, upon a rather heavy brass frame as shown in the illustration. The frame of this mount consists primarily of two brass bars $1'' \times 1'' \times 6''$ which carry, on their lower sides, small wheels

placed in milled recesses. Guides are also provided so that the frame of the vibrator will stay on the sides of the tank. In use it is only necessary to pluck the vibrator and then move the supporting frame. The results obtained are very gratifying as the reader may judge from the accompanying photograph. In taking the photograph for this illustration it was necessary to use an exposure of 1/5 of a second. In this length of time the waves moved sufficiently to produce a lack of sharpness which does not occur in the demonstration.

ROADS TO CREATIVE TESTING IN HIGH SCHOOL SCIENCE

By Leon Nordau Diamond
Thomas Jefferson High School, Brooklyn, New York

At the present time most of us are agreed, at least in theory, that in the ideal school situation the student should be interested in his work if worth-while results are to be obtained. Coming now to tests, the question is: How interested are students in taking them? Obviously, there can be no absolute answer, inasmuch as their attitude hinges upon a variety of complex factors: the type of test, the amount of material covered, and many others. Nevertheless, the chorus of disgusted Oh's and Ah's greeting the ears of the teacher when a test is announced would appear to furnish some evidence that examinations are, to say the least, distasteful. It seems obvious, therefore, that some thought should be devoted to a consideration of how to affect for the better the attitudes of students towards tests. True, many are convinced that pupils will always dislike taking them because the irksome task of reviewing the past work is involved. However, the writer believes it to be entirely feasible to change this attitude for the better save for those few students who will always resent a "show-down" on their lack of achievement.

Some time ago, four of the writer's classes were given an essay-type test based upon a unit of work in biology. As soon as they had finished, the students were given a mimeographed sheet bearing the following instructions:

> Below you will find a list of ten possible ways to spend an hour. Read the list carefully and then decide which of the ten you would like most to do. Place the number one (1) in the parentheses to the right of your choice.

Then decide which of the nine remaining possibilities you would next prefer to do. Place the number two (2) in the parentheses next to this choice. Continue until you have numbered all ten possibilities in the order of your preference. (The results for this first questionnaire, based upon the essay-type test, are shown in column I.)

	I.	II.	III.	IV.
1. Go swimming.[1]	(1)	(2)	(1)	(1)
2. Go to the movies.	(2)	(1)	(2)	(2)
3. Do an experiment in biology.	(3)	(3)	(4)	(4)
4. Listen to a lecture on biology.	(4)	(4)	(5)	(5)
5. Read your textbook.	(5)	(6)	(6)	(6)
6. Run errands for your mother.	(6)	(8)	(8)	(8)
7. Do written homework in biology.	(7)	(7)	(7)	(7)
8. Take a test similar to the one just taken.	(8)	(5)	(3)	(3)
9. Wash the dishes after supper.	(9)	(9)	(9)	(9)
10. Stay after school for bad behavior.	(10)	(10)	(10)	(10)

While it is true that other factors, i.e., the difficulty of the unit[2] may have contributed to the above results, still it is evident that the essay-type test is unpopular with the student. The somewhat onerous task of running errands for mother is preferred! Moreover, numerous conversations with the students served to verify this.[3]

Three weeks later, they were given a new-type test consisting of 30 true-false, 20 completion, 10* multiple-choice, and 10 matching items. Again they were given the questionnaire to fill out. From the results seen in column II, it may be seen that the task of taking a "test similar to the one just taken" had advanced from the eighth to the fifth place; indicating that this type of test is much more to their liking than the essay-type.

This procedure was pursued a step further. Boys and girls of high school age, if given only a little encouragement, can do surprisingly well those things which we are prone to believe only teachers can do. To a deplorable extent we tend to assume all initiative and responsibility in the classroom, thus cutting down upon the creative opportunities of the student. We fail to realize that it is through precisely those activities which we so unnecessarily take upon ourselves that true growth and education are to be fostered.

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[1] The above ten choices were not presented in the order given lest it influence the student.

[2] The unit in question was the structure of the digestive system.

[3] Similar results were obtained by a fellow science teacher who employed the identical procedure in verifying the results of all four columns. Altogether, 201 students took part in the experiment.

* The results given in column I should not be interpreted as meaning that the essay-type question should be abandoned. There are many excellent reasons which might be advanced for its inclusion in tests.

Allowing the students to devise their own tests is an excellent means for increasing their "creative opportunities." In practice, this was accomplished by the writer and each of his classes jointly selecting a committee of four students. Their duties were not only to devise but to administer and mark tests.

After two new-type tests had been written and administered by the committee for each class, the students were again given the questionnaire to fill out. The results, seen in Column III, show them to be overwhelmingly in favor of their own tests. Thus, the use of this simple procedure seems to be a step in the right direction whereby interest in tests will encourage effort on the part of the student.

However, we have not yet exhausted the possibilities of stimulating interest and effort in testing. With the system of marking which we now employ, we tend to set student against student; encouraging them to "beat" their neighbor. Vicious effects are often produced in that the backward child is hopelessly discouraged by his consistently low standing while his brighter neighbor is spoiled. This undesirable state of affairs may be minimized by the simple device of having students compete for marks, not against their fellows but against themselves. To achieve this, the first requirement is for the teacher never to divulge a student's grade to the rest of the class. The second is to have each student graph his test results so that he may be in a position to see at a glance whether or not he is making progress.

However, a difficulty which arises is this: a mark of 85% received by a student in one test may be the equivalent of 65%, let us say, received in another. This follows from the fact that tests vary in difficulty. In this case, a student's graph would have no meaning since the drop of 20 points is only a seeming drop. This difficulty may be avoided by the simple device of ascertaining the central tendency—mode, mean, or median[4]—of a class or of a number of classes in preceding tests. This will give us a *standard* mode, mean, or median. The next step is to obtain the central tendency of the test which we desire to graph. For example, let us assume that our standard mean (the arithmetic average of a number of classes in preceding tests) is 72% and that the test which is to be graphed has a mean of 67%. This would indicate, roughly speaking, that the test is more difficult

[4] For information as to the derivation of the mode, median, or mean, any elementary textbook of educational statistics is suggested.

than usual. Consequently, the difference between the two means (5%) should be added to all the grades of the test. Similarly, if the mean of the test to be graphed is 79%, the difference (7%) should be subtracted from all the grades before returning the papers.[5]

The writer found that the practice of graphing supplied an astonishingly potent form of motivation both for dull and bright individuals. Altogether, three new-type tests (devised by the writer) were given the students to be graphed. At the end of the third test, the questionnaire was again administered. The results, seen in Column IV, conclusively demonstrate the popularity of graphing with students.

Besides the above, there are other, perhaps more artificial means of stimulating interest in tests. To begin with, why not use new types of questions? In the past, we have ignored the fact that new varieties of test items not only add interest and zest to testing, but may also measure certain types of information more effectively than do those in common use. A favorite of the writer is the code-type of question.

Instructions: By finding out what each letter of the following code word stands for, you will discover the name of a great scientist whose work will be taken up later.

U	N	Q	S	A
( )	( )	( )	( )	(H)

Solve it as follows:

Letter A: Place an H in the parentheses below letter A if carbon dioxide is given off in respiration. If it is not given off, place the letter P below letter A. (Since this gas is given off, H is correct. Consequently, it is placed below letter A.)

Letter N: Change to O if root hairs take in soil water through the process of osmosis. If they do not, change to E.

Letter S: Change to N if lack of vitamin D causes scurvy. Change to C if lack of vitamin D causes rickets. Change to R if lack of this vitamin causes beri-beri.

Letter Q: Change to E if haemoglobin is not present in red blood cells. If it is present, place *nothing* in the parentheses below letter Q.

Letter U: Change to S if the ovary of a flower is part of the perianth. Change to K if it is part of the pistil.[6]

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[5] It should be noted that there are more accurate methods of equating tests. Nevertheless, it will be found that the above method is the most convenient for ordinary use.

[6] The following references may prove useful in devising new types of questions: Webb, Hanor A., *Variety, The Spice of Testing*, General Science Quarterly, 13: 93–98, January, 1929.
Meister, Morris, *Twenty Ways to Test Your Class*, The Science Classroom, Vol. XI, Nos. 5–6, February, March, 1932.

The use of contests is also suggested. In practice, the writer divides the class into two equal sections. The students are then given slips of paper, each bearing a question based upon a previous unit or units of work. After five minutes, a member from each group recites alternately. The writer acts as referee, deciding whether the answers are correct, partially correct, or incorrect. His decision may be challenged by any member of the class. It will be found that such contests are amazingly effective in provoking a critical and questioning spirit on the part of the students, especially if the teacher encourages them in defending their views. It is, perhaps, not too far-fetched to say that this is in accordance with the spirit of science as contrasted with that of authority; in accordance with the spirit of Galileo who, when forced by the Inquisition to recant the statement that the earth revolves about the sun, is said to have muttered under his breath "Eppur si muove"—and yet it moves.

As we all know, students who have just completed an examination are especially eager to go over it with someone who can check their work. Why not harness this splendid learning attitude by going over the answers as soon as possible? Common sense would indicate that the teaching value of a test is especially high if it is gone over immediately and that there is a sharp decline in this value if much time elapses between the time a test is given and the time it is gone over. So the motto of the teacher after giving an examination should be to "strike while the iron is hot."

A final point which cannot receive sufficient emphasis is this: we must endeavor to give the student some sort of insight into the purposes of testing. In too many instances, he has little understanding of what is expected of him other than a high mark. He fails, as a rule, to realize that one of the most important, if not the most important function of a test is to have him review his work for permanent acquisition. Can we wonder why the practice of last-minute cramming is well-nigh universal?

The responsibility for this state of affairs falls squarely upon the teacher. He, too, requires more insight into the aims and purposes of testing. This, alone, can do away with so-called tests of science, depending largely upon memoriter knowledge of the textbook. It is, perhaps, unnecessary to dwell upon the fact that memorization of the facts of the text kills a science and that examinations, based upon these same facts, buries it.

SCIENCE EXPERIMENTS WITH FIVE AND TEN CENT STORE EQUIPMENT

By T. J. Kuemmerlein
Boys' Technical High School, Milwaukee, Wisconsin

The local five and ten cent store can be the source of supply for many science experiments. Many of these experiments can be used in both physics and general science. They might be used as demonstration lessons or as lessons for the individual students. Experiments with this kind of apparatus can be used by the student in his home or in the laboratory.

While these experiments illustrate and demonstrate many principles of physics and science, they are not intended to take the place of any of the more accurate apparatus which we find in science. This apparatus is not intended to supplant the high grade equipment which is essential to accurate work in science. These experiments, however, can be used to supplement courses in general science where the needed equipment might be too expensive to purchase. These experiments might also be used as supplementary projects and assignments for the more advanced students in the course.

AIR PRESSURE

The fact that air exerts a tremendous pressure on all objects can be illustrated by a number of experiments. The air pressure coat hanger makes use of a common device which we see quite often. It consists of a concave rubber disk with a metal hook on the reverse side. When the disk is moistened slightly and pressed firmly against a smooth surface most of the air in the concave area is forced out, creating a partial vacuum. This vacuum allows the air pressure to hold it tightly to the surface. It will be found that it takes a very considerable force to remove it from a piece of glass.

Another device to illustrate a practical use for air pressure is the atomizer. One type consists of two tubes at right angles to each other. The person using the atomizer blows into the one tube which causes a stream of air to blow across the other tube. This second tube extends into the liquid. When the stream of air blows across the top of it, some of the air in that tube is removed, thus reducing the air pressure on the liquid. The air pressure on the rest of the liquid in the bottle is greater, so it is forced upward into the stream of air blowing across this tube. The

liquid is then changed into a spray of finely divided particles. Another type of atomizer has an air pump or a rubber bulb to supply the stream of air. This type will show how the air can be compressed in addition to demonstrating the atomizing principle.

The common medicine dropper is a simple device that can be purchased in these stores. This device illustrates how air can force a liquid up a tube. This can also be used to show how the "self-filling" fountain pen operates.

HEAT

In the study of heat there are a number of experiments that can be worked with this kind of apparatus. One of these is an experiment to show how the radiant energy of the sun can be changed into heat energy. A cigar box, lined with black cloth and covered with glass, in which is placed a thermometer is all that is needed. When placed in the sun, the temperature will raise considerably. If another box similar to the first one, only lined with white cloth instead of black, is placed beside the first, a marked difference in temperature will be noted.

Metal thermometers are also available with which to demonstrate and explain, expansion and contraction of metals.

Two screw eyes of different sizes so that one will not quite pass through the other, will make the apparatus that is a variation of the "ring and ball" experiment. Upon heating the larger eye, the smaller one will then pass through it.

A very satisfactory wet and dry bulb hygrometer for determining the relative humidity of the air can be made with inexpensive equipment. Two ten cent thermometers form the basis for this device. The instrument is simply two thermometers hung side by side on a board. The bulb of one is surrounded by a wick which is kept moist by a vessel of water. The evaporation of the water from the wick, cools the liquid in the thermometer thus causing it to read lower. With greater evaporation a lower temperature will be indicated. Thus the difference between the two thermometers will be greater. From a suitable table of wet and dry bulb readings, the relative humidity can be determined. This experiment can be used to bring out the principle involved in the contraction of liquids upon cooling, and the cooling of objects by evaporation.

ELECTRICITY

The supplies for a number of experiments in electricity can be obtained in the five and ten cent store. The energy can be

obtained from dry cells, the various sizes of which are available. Different sizes and coverings of wire can be purchased in convenient ten cent spools. This wire when wound around a bolt will make a powerful electro-magnet. This electro-magnet can be made into a simple telegraph set by having it attract and release a metal bar providing a signal.

A coil of nickel-chrome resistance wire for replacement in toasters and heaters is another article that is available in these stores. This wire will furnish enough resistance when connected in series with a pair of carbon rods in a 110 volt circuit, to make an arc-light. The principle of the arc-light can be illustrated very nicely with this apparatus.

This wire can also be used to show the heating effect of an electric current. The wire can be stretched tightly between two points. Then by connecting it across a 110-volt line, it will become red hot. With the heating of the wire, a corresponding lengthening will be noted showing expansion by heating.

The stores also have small pocket compasses and small horseshoe magnets which are suitable for a number of experiments in magnetism. A workable galvanometer can be made by enclosing a compass in a coil of fine wire.

The principles of the electric motor can be very efficiently taught with the aid of a toy electric motor, which costs but ten cents. This motor can be assembled by the student, and can be used for a number of experiments which are explained in the SCHOOL SCIENCE AND MATHEMATICS for October, 1932.

LIGHT

The work in astronomy in general science can be made more real and interesting if one has a telescope. A good telescope is quite expensive and not always readily obtainable. However, a very satisfactory one can be made very simply by the pupils or instructor. Some of the stores sell spectacles for twenty-five cents a pair. One of the lenses of these can be used for the object glass of the telescope. By securing spectacles that have a long focal length (thirty or forty inches), you have the object glass. The eyepiece is not a ten cent store article, but can be purchased for about fifty cents. This eyepiece can be any short focus lens about one inch or less. Opticians sell a weaver's glass, or linen tester, which has a satisfactory lens. These lenses if mounted in tubes made of rolled paper that fit inside of one another so that you can focus the instrument, will make a very

excellent telescope. The interest that this will create in the average science class is amazing.

SOUND

Some of the principles of sound can be shown by the toys that are sold in these stores. A toy violin that has both metal and gut strings can be used to show many of the principles. Whistles, bells, mouth accordians, and orchestral bells are some of the toys that belong to this class of article.

REPAIRING BROKEN MERCURY COLUMNS IN THERMOMETERS

By J. R. Endsley

Freed-Hardeman College, Henderson, Tennessee

Frequently instructors find thermometers with their mercury columns broken into short sections which are so widely separated that their accuracy is greatly diminished, if not rendered entirely useless. These may be repaired, in most cases, at least, by anyone with but very little experience if he will carefully follow the method described below. These suggestions may not be new to many but since the writer has never seen them in any publication he passes them on with a hope that they prove helpful to someone.

Adjust a medium size ring on a ringstand so that it will be at the proper height for heating objects upon it with a low flame. Lay a wire gauze upon the ring and set a small beaker, 50–100 cc. upon it. Insert the thermometer into a cork or rubber stopper, leaving whichever is used three or four inches from the top. Place a plain burette clamp on the ringstand so that it extends out over the beaker. Now put the cork or stopper with the thermometer in the clamp and adjust the latter so that the mercury bulb of the thermometer is one-half inch or more above the bottom of the beaker and fasten there securely. Add enough glycerine to cover the mercury bulb; some other liquid with a high boiling point may be used instead of glycerine. And for thermometers with a range above such liquids a salt or compound with a low melting point but which does not boil too low may be substituted.

Heat the beaker slowly, very slowly toward the last, till the mercury below the last gap in the column rises into the cavity at the top of the tube. Then remove the burner and gently tap the thermometer, near the top, as the temperature drops slowly. And it is almost certain that the mercury will leave the cavity as a continuous column. It has never failed to work the first time for the writer, but should it not be successful at first repeat the heating and tapping as directed. The writer has never had occasion to try the above method on a thermometer which has no cavity at the top of the mercury tube but he believes that the procedure may easily be modified so as to handle such cases.

After trying the above method, Mr. T. A. Frick, of Hiwassee College, suggests that he finds in case the mercury has been driven up into the cavity at the top of the tube and is stuck, by careless students, that it can be easily dislodged by inverting the thermometer and heating the upper end of it till most of the mercury has been driven out of the cavity and suddenly righting again. The tendency is for all the mercury to run back down the tube and form one unbroken column.

GRAPHS IN CHEMISTRY

By Ralph E. Wellings
Dorchester High School for Boys, Dorchester, Massachusetts

Students in high school will faithfully memorize the gas laws and their formulas too, if you let them. But you shouldn't let them, until they understand the meaning of each law.

With my classes I use the following method and my pupils understand the laws as far as high school pupils are required to understand them.

First, demonstrate that if you double the pressure you cut the volume of the confined gas in half. This is essentially Boyle's law.

Second, suppose that you have 50 cc. of a gas under 760 mm. pressure. Now you double the pressure, what will the volume be? Let $V = 50$ cc. and $P = 760$ mm. and $P' = 2 \times 760$ or 1520 mm. Then $V' =$ the answer. The class at once understands that the answer will be 25 cc. At this point the proportion 50 cc. is to 25 cc. as 1520 mm. is to 760 mm. can be arrived at easily. Substituting letters for numbers you have V is to V' as P' is to P or $VP = V'P'$. The method is inductive.

Third, let the class suppose that they have 24 cc. of oxygen (V) at 0° and 760 mm. (P). Assuming that there is no change in the temperature, allow the pupils to calculate what the volume would be theoretically with each change of pressure in the following examples.

1. $V' = ?$ $P' =$ 1520 mm.
2. $V' = ?$ $P' =$ 6080 mm.
3. $V' = ?$ $P' =$ 12160 mm.
4. $V' = ?$ $P' =$ 24320 mm.

The teacher should have the graph lines already drawn on the blackboard. The first point on the graph will be on the 24 cc. mark on the 760 mm. line. The second point will be where the line drawn horizontally from the 1520 mm. point meets that drawn vertically upward from the point which is obtained as the answer to the first problem. This procedure is followed for each of the five points and a colored line is then drawn through the points. This line is the graph of Boyle's law. (Fig. 1.)

Fourth, have each pupil pick out a point, (such as A, fig. 1)

on the curve, other than the five already obtained, and find its value in cc. and mm. using only a ruler.

Let each student then assume that his volume for each point is correct and work the problems to verify his reading of the number of millimeters.

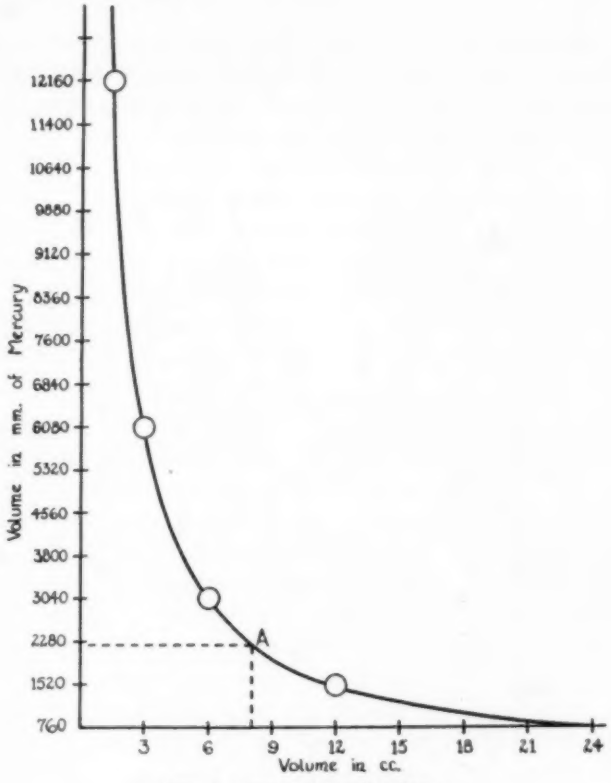


FIG. 1. Graph of Boyle's Law.

The first three points of this procedure have been carried to completion during a forty minute class period. The fourth point is taken on the following day. The results have been excellent.

Last year and again this year I taught this graph lesson and each time I required the pupils to repeat the procedure at home using 50 cc. of oxygen at one atmosphere to start with and cutting the volume in half each time to find the resulting pressures.

The values of the graphic method in chemistry are:

(1) Even if the student forgets the teacher's wording of the law

he really knows the meaning of the law, which is the chief objective desired.

(2) The graph puts a picture in the archives of the photographic memory. It is visual education. As one student told me, "A lot of words become a line I can see and read the meaning of."

It is needless for me to lengthen this paper by a detailed explanation of the method of graphing Charles' law. The same procedure obtains. A typical graph, showing the values put on the board, will illustrate the result. (Fig. 2.)

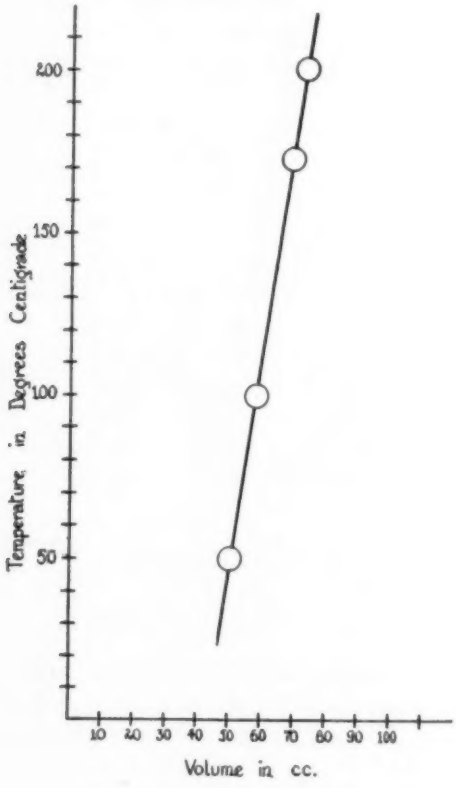


FIG. 2. Graph of Charles' Law.

[In Fig. 1 "Volume in mm. of Mercury" should read "Pressure in mm. of Mercury"—Ed.]

Laws for the liberal education of youth, especially of the lower classes, are so extremely wise and useful that, to a humane and generous mind, no expense for this purpose would be thought extravagant.—JOHN ADAMS.

A SIMPLE RESONANCE SPRING

By Thomas D. Phillips
Marietta College, Marietta, Ohio

A device which demonstrates the transfer of energy from one mode of vibration to another when the two are in resonance is described below. The apparatus serves the same purpose as the so-called Wilberforce and Sommerfeld springs and is much more easily constructed in the laboratory.

Clamp a spiral spring so that it hangs from a rigid support. Bend a hook in the lower end of the spring in such a way that the hook is at one side rather than on the axis of the spring. Now hang weights on this hook until the period of vibration of the device, to-and-fro, as a pendulum, is related to the period of vertical vibration of the spring in a ratio of two to one. If now the spring is set into vibration either as a pendulum or vertically a transformation will occur from the initial form of vibration to the other and back again in repeated cycles.

Almost any spring will do. The only limitation is that the relation of length and stiffness must be such that the condition of relative periods specified above can be obtained.

Besides its ease of construction the device has the further advantage from a demonstration standpoint that the explanation of the shift from to-and-fro to up-and-down motion and vice-versa is simple. As the spring swings to-and-fro, as a pendulum, the tendency of the weight to maintain its motion in a straight, horizontal line rather than an arc causes a downward pull on the spring as the weight nears the ends of its path. If the natural period of up-and-down motion of the spring is one half that of the to-and-fro motion of the pendulum these downward pulses will be properly timed to accentuate the up-and-down motion and the result is a nearly complete transfer of energy from the to-and-fro motion to the up-and-down motion. On the other hand, if the spring is vibrating up-and-down a slight horizontal impulse is given to the weight with each vibration due to the unequal stretching of the two sides of the spring. As a result, if the natural periods are related as above, these periodic impulses will be cumulative and the to-and-fro motion will be increased until nearly all the energy has been transferred from the up-and-down to the to-and-fro motion.

If the system is so chosen that the net damping is small, the process will continue for a considerable number of cycles.

WHY IT IS UNSAFE TO SWIM NEAR A PIER DURING A THUNDERSTORM

By Morris Wistar Wood
Culver Military Academy, Culver, Indiana

Many people, even those with some scientific training, might believe that a swim near a pier during a thunderstorm would be a mildly exciting, but perfectly safe diversion. They would argue that swimming in an open lake might be dangerous, but the pier would protect them from lightning, should it happen to strike nearby. When the swimmer's head is the highest point in the neighborhood, he is in danger, as the bolt will take the best conducting path to ground, but for this very reason, a swimmer near a pier would be perfectly safe.

While this argument may be a theoretical half-truth, a thunderstorm in Indiana was sufficiently shocking to fully convince the writer that some very important points in addition to the ones just mentioned, must also be considered. A party of eight or ten persons, including the writer, went sailing on an inland lake several miles in diameter and of circular shape. The weather was decidedly threatening, but we hoped the storm visible on the horizon would pass to the north of us. As the clouds continued to climb higher in the sky we decided to put back to shore, as a few distant flashes of lightning were visible.

We landed all the passengers except my nine-year-old son, at a pier some hundred yards long, and then the two of us, in bathing suits, put out to the mooring. We had not quite finished furling the sail when we saw a heavy rain coming toward us, a mile or so away, and by the time we had the boat securely fastened the storm was upon us. We both dived off the boat and swam the short distance to the pier, thru the very heavy rain. I had just helped the youngster out of the water when large hail stones started to fall. To get away from these as quickly as possible, I went under the pier, to the lee side, where I held on to a two inch iron pipe, which was part of the framework of the pier. These vertical pipes ran from the top of the canvas roofing of the pier down past the floorboards and thru perhaps eight feet of water to the ground.

Scarcely had I grasped this pipe when a brilliant flash occurred, simultaneously with the thunder. I felt a violent electrical shock thru the hand grasping the pipe, and on thru the arm, body and legs. My first kick, in an effort to swim was un-

successful, but the momentary paralysis perhaps lasted ten seconds or less. I let go of the pipe and swam ten feet or more to the leeward, trying to keep my body in a horizontal position on the surface of the water. I did this because I thought my body would now make a smaller part of the path from air to ground, and by keeping away from the metal of the pier, I expected to be perfectly safe.

A second stroke of lightning followed the first, and to my surprise, I felt it throughout my whole body. As I believed this possible only if the pier had been actually struck, I was glad to see my boy standing on the pier, with his hands clasped tightly over his ears. He was standing on a wooden floor, drenched by the rain, but had felt no electric shocks whatever. The pier showed no damage except that caused by the wind, which washed overboard a bench and some folding chairs. So if the pier was struck by the main bolt, the two inch iron pipe framework was sufficiently heavy to handle the current. Both shocks were very close to us, as no time was noticeable between lightning and thunder.

In seeking an explanation of these phenomena we must first emphasize the fact that any electric spark is of an oscillatory nature, and sets up induced voltages in the neighborhood. F. W. Peek Jr. in his paper on lightning read before the Franklin Institute in 1924 shows very clearly that damage to electrical transmission lines and connected apparatus is usually caused by induced currents rather than by the direct bolt. The same theory is brought out in the "Code for Protection against Lightning," *Handbook of the Bureau of Standards, No. 17*, and in a monograph published in England entitled "Atmospheric Electricity," by B. F. J. Schonland. I have talked to several people of unquestioned integrity who have seen "A ball of fire as big as a basketball" either come down a chimney, or jump out a window, but none of them reported feeling any electric shock at the same time. If this ball of fire type of lightning is not illusory, it apparently is not the kind that does the most damage. The Bureau of Standards handbook shows a photograph of a flash taken by Dr. Walter, with a moving camera, which clearly shows the oscillatory nature of the spark, which infers the possibility of heavy induced effects in conductors nearby.

To quote Peek, "It is a well established fact that during any thunderstorm there are likely to be induced many low voltage impulses, a less number of moderate impulses, and frequently

none of high voltages." He found also that lightning does not always strike the highest object. If you assume a cloud 1000 feet high, a six foot man, on a plane directly under the storm center would be hit fifteen times out of every hundred strokes, while a 25 foot building would be hit every time. A man lying flat on the ground would be hit only once in a hundred strokes. In view of these figures we might assume that the pier was actually struck, as it stood perhaps 15 feet above the water, at the top of the ridge pole. But if this were true, the boy on the pier would probably have felt a shock of some kind. A number of sail boats were moored nearby, with masts as high as the pier top. None of these showed any evidence of a direct hit.

Wherever the lightning actually struck, a large difference of potential was apparently induced between the top of the iron posts and the ground under the water. Certain calculations led Schonland to believe that some lightning charges build up to perhaps a billion volts pressure, and he states, "When a storm passes overhead voltages of 20,000 volts per meter are commonly observed." A conservative estimate would then allow 10,000 volts between the top and bottom of the iron pipes of the pier. In that case, the water near a post would be at a different potential from water at a distance, and water near the surface would be at a different potential from water near the bottom. The water of this lake is a good conductor, due to the presence of large amounts of iron salts and other minerals in solution. As my toes were six feet or so from my head, I might easily receive 100 volts or so,—quite enough to be uncomfortable when wet. This pressure could have been five times as great, in which case it would probably be fatal.

BLOOD PIGMENT FACTORY IN LIVER DESCRIBED

Hemoglobin, the stuff that makes blood corpuscles red, is produced in the liver at widely differing rates, depending on what ails you, Prof. G. H. Whipple of the University of Rochester School of Medicine has discovered in a long series of experiments.

He compared human liver tissue with that of experimental animals and found that normal human liver contains much more of the hemoglobin producing factors than does normal dog liver. Certain types of acute infection reduced somewhat the store of these potent hemoglobin factors in the human liver, and cirrhosis or hardening of the liver reduced it by more than two-thirds. But in anemias of several different types there was an increase in the hemoglobin factors, in spite of the impoverished condition of the blood itself.—*Science Service.*

A GRAPHIC DETERMINATION OF THE COMPLEX SOLUTIONS OF THE QUADRATIC EQUATION $x^2+ax+b=0$

By Günther Wünsche
Graduate Student, Technical University of Dresden, Dresden, Germany

The quadratic equation may be written in the form $x^2+ax+b=0$. In the present discussion we consider the case in which $a^2-4b<0$. In this case the given quadratic equation has two conjugate complex roots. We write these roots in the form

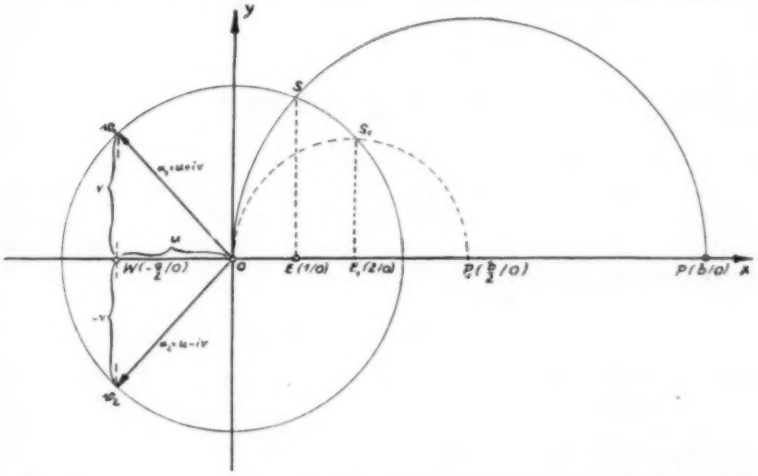
$$\alpha_1=u+iv=re^{i\phi} \text{ and } \alpha_2=u-iv=re^{-i\phi},$$

where $r=\sqrt{u^2+v^2}$ and $\phi=\arctan u/v$.

According to the law of Vieta the relations $-(\alpha_1+\alpha_2)=a$ and $\alpha_1\alpha_2=b$ must exist. Hence we find, using the formula of Euler, $e^{\pm i\phi}=\cos\phi\pm i\sin\phi$, that

$$a=-r(e^{i\phi}+e^{-i\phi})=-2r\cos\phi \text{ and } b=r^2(e^{i\phi}+e^{-i\phi})(e^{i\phi}-e^{-i\phi})=r^2.$$

We now put these derived values of a and b into our given quadratic equation and obtain the form $x^2-2rx\cos\phi+r^2=0$.



If we wish to determine the two complex solutions of this quadratic equation by the help of a geometrical method, we need only construct the radius vector r and the amplitude ϕ. After having done this, the coefficients u and v of the real and of the imaginary part of $u\pm iv$, respectively, are read from the drawing very easily.

The geometrical figure from which we determine the values of the complex solutions is constructed in the following simple manner. After having fixed a rectangular system of coordinates, we construct the circle of Thales of diameter $OP = b$ on the x-axis. We erect at the point $E(1, 0)$ a perpendicular which intersects the circle of Thales on OP in the point S. With the radius OS we construct the circle which has its center in O. Through the point $W(a/2, O)$ we draw the perpendicular which intersects the latter circle drawn about the point O in two points. Their abscissas and ordinates give us the required values of u and v. Moreover, the vectors v_1 and v_2 are the geometrical representation of our pair of conjugate complex roots. The proof of this statement is made very easily.

If the point S is not determined with sufficient precision by a "sliding intersection," we may alter our construction so that we may use the circle of Thales on the diameter $OP_1 = b/2$. Then we must draw the perpendicular through the point $E_1(2, O)$ and we obtain the same radius $OS_1 = OS$.

The advantage of this method for finding the complex solutions geometrically, as opposed to the other usual methods in which a parabola or other conic section is used, is obvious.

SCIENCE QUESTIONS

May, 1933

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

Please send copies of Tests and Examinations to Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

PORTRAITS OF GREAT SCIENTISTS

618. *Proposed by Matthew Halverson, Custer County High School, Miles City, Montana.*

Can you suggest where I can obtain a large portrait of Galileo which I can frame and hang in my class room?

I will be very grateful for this suggestion.

Answer by P. A. Tapley, Physics Dept., Central High School, Beloit, Wisconsin

"I have recently been in touch with A. Gallenkamp Co., of London who supply such pictures at about $1.00 each. I have recently received a letter from General Biological Supply House (Thurtox) of Chicago and they are attempting to secure the U. S. Agency for these pictures. One may also secure them by writing directly to London."

QUESTIONS ON THE MAPLE SUGAR INDUSTRY: A UNIT OF STUDY

619. *Proposed by Wm. G. Vinal, Ph.D., School of Education, Western Reserve University.*

These questions are published in full in the March, 1933, number of SCHOOL SCIENCE AND MATHEMATICS, *pages 348 and 349.*

Please refer to the March number and compare your answers with the following.

ANSWERS TO QUESTIONS ON THE MAPLE SUGAR INDUSTRY

By William G. Vinal, Western Reserve University

1. Christina C. Rossetti in "The First Spring Day."
2. "Treacle" is the sirup drained from sugar in refining. "First run" is the first sap to flow and is usually considered the best. "Season" is the few weeks that the sap is flowing. "Stone-boat" is the sled which is drawn by horses or oxen to bring in the sap to the sugar house. "Caldron kettles" are the large iron kettles in which the sap was formerly evaporated. "Sugar off" is the changing of the thick sirup to sugar.
3. In colonial times maple sugar was considered a necessity. It is now a luxury.
4. The honey locust bean has 29% sugar and the sap of the sugar maple is 3–6% sugar.
5. The leaves are the factories where starch and sugar is manufactured.
6. Rhode Island.
7. Maple sugar is an American product. It is not made in Europe.
8. The axe is used to cut firewood and not to scarf the trees.
9. Thawing days and freezing nights.
10. Sharp-pointed buds with many bud scales.
11. To make new leaves and wood.
12. The Indians made the sap spout from sumac or elder stems. They are now made of galvanized metal.
13. The wounds made by the augur usually heal in one season and are not infected.
14. The Indian dropped hot stones into the sap. When it froze he threw the ice away.
15. Three to four weeks.
16. The sap comes from all parts of the tree. If you break a twig it will "bleed". It comes from above and from below. During the first part of the season more comes from above.
17. South.
18. When the tree is warmed the air in the cell spaces expands.
19. Sapsucker, porcupine, redsquirrel, insects (Flies and bees).
20. Bark and hollowed logs.
21. 32 quarts.
22. ½ inch augur, 2 inches deep; breast high, slanting up.
23. Up the sap wood and down the inner bark.
24. For individuals to carry pails of sap to kettle to be "boiled down." It is a piece of wood that goes across the shoulders to hold a pail on each end.
25. So that one can use a siphon and run sap by gravity.
26. To remove impurities such as bits of ashes, bark etc.
27. By putting in cream, lard, or salt pork to break the surface tension of foam.

28. Eleven.
29. Hot liquids contract when cooled.
30. They had to attend to sap buckets in the day.
31. Although the sugar maple makes the best sugar it is also made from the red and silver maples.
32. By pouring driblets of thick sirup on clean snow.
33. Vermont produces the most sugar and New York the most sirup.
34. Brown sugar as it is cheaper.
35. By evaporation.
36. Furs, corn, and maple sugar.
37. 1–6 pounds.
38. It concentrates to the point where it is no longer soluble in the water present.
39. In 1860, 40,120,205 pounds. In 1910 14,000,000 pounds. In 1920, 9,691,854 pounds. These are estimates from the U. S. Census.
40. The boiling point of a liquid varies with the altitude and also concentration.
41. A hydrometer, usually the Baume.
42. Conductor of heat which is necessary for evaporation.
43. Lower priced, steady supply, and modern machinery for refining.
44. Trees are scattered and mostly hand labor.
45. The flowers and leaves come together in the sugar maple.
46. Bacteria.
47. The fruit comes from end buds in the sugar maple and from side buds in the red maple.
48. The cause of bird's eye and curly maple is unknown. It is not due to woodpeckers.
49. Although once thought of as food it is now considered a confection.
50. The maple tree borer is a kind of beetle.

GOLD

620. What is the specific gravity of gold?

A hoarder came into the Federal Reserve Bank at Cleveland with certificates calling for $82,000 in gold coin. How much did it weigh?

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621. "Pop Eye," the sailor, cast his $10,000,000 of gold into a cube to protect it from thieves. How large was the cube?

PIPERIDINE VANADATE

A new member of the family of chemical substances that turn dark on exposure to light was announced by Dr. Oskar Baudisch of Yale University and Dr. F. L. Gates of Harvard University. This is piperidine vanadate. Its crystals change from their original white to black or brown on exposure to light just a little down the wave-length scale from the invisible ultraviolet. It is the light-sensitiveness of certain silver compounds that forms the whole basis for the photographic and motion picture industries. The new compound, however, is still so new that practical applications have not yet been suggested.—*Science Service.*

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS OF PROBLEMS

Note. Persons sending in solutions and submitting problems for solution should observe the following instructions:

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem proposed if you have one and also the source and any known referrences to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTION

1262. Lewis and Clark Mathematics Club, Spokane, Washington. H. R. Mutch, Glen Rock, Pa.

1268. *Proposed by Charles Lauthan, Columbus, Ohio.*

Find the indefinite integral $\dfrac{(\log x)^5}{x}dx$.

Solved by E. T. Morgan, LaBelle, Missouri

$$\int\frac{(\log x)^5}{x}dx = \int(\log x)^5 d\log x = \frac{(\log x)^6}{6} + C.$$

Also solved by Charles W. Trigg, Los Angeles, Harold G. Shirk, State College, Pa., D. Moody Bailey, Athens, W. Va., John E. Bellards, St. Nazianz, Wis., E. W. Buker, Leetsdale, Pa., S. Fenicfel, Newark, N. J. H. S. Mutch, Glen Rock, Pa., G. M. Weld, Watertown, Conn., and O. A. George, Mason City, Iowa.

1269. *Proposed by C. C. Hunt, Cedar Rapids, Iowa.*

On sides AC and BC of the triangle ABC, construct parallelograms $ACHI$ and $BCGF$ external to the triangle. Produce IH and FG to meet at K. Draw KC and extend it to meet AB in R. At A and B draw lines parallel to KR meeting IK in D and FG in E. Prove that $ABED$ is a parallelogram whose area equals the sum of the areas of the parallelograms $ACHI$ and $BCGF$.

Solved by H. R. Mutch, Glen Rock, Pa.

PROOF: $ADKC$ is a parallelogram, for the opposite sides are parallel, hence, $AD=CK$, also $AD\|CK$.

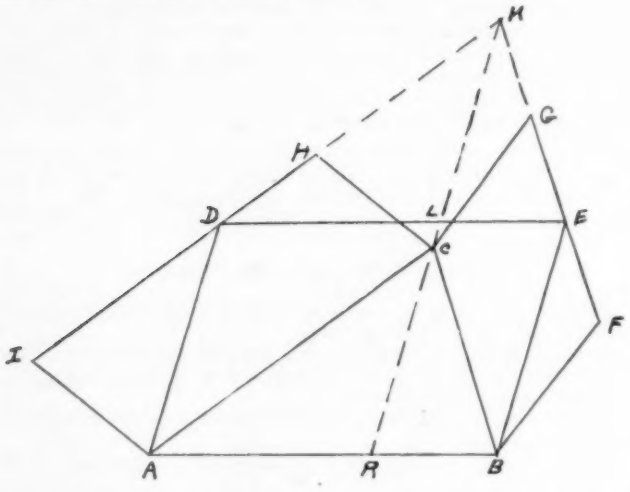
Similarly, $BE=CK$, and $BE \| CK$.

Therefore, $ABED$ is a parallelogram.

Hence, $AIHC=ADKC=ADLR$ for the parallelograms have equal bases and equal altitudes.

Also $BFGC=BEKC=BELR$ for same reason.

Adding $AIHC+BFGC=ABED$.



Also solved by Richard E. Gadske, Carbondale, Ill., D. Moody Bailey, Athens, W. Va., John E. Bellards, St. Nazianz, Wis., Wallace. H. Deebeh, Roselle, N. J., D. A. Turnipseed, Fargo, N. D., Angie L. Rogers, Dexter, N. M., W. E. Buker, Leetsdale, Pa., Mack Tucker, Bremen, Ind., Adrian Struyk, Paterson, N. J., Charles W. Triggs, Los Angeles, A. MacNeish, Chicago, Ill., and the author.

1270. *Proposed by Norman Anning, University of Michigan.*

The equation $x^{10}=10^x$ has two roots other than the obvious root 10. Find the negative root correct to four significant figures.

Solved by Adrian Struyk, Paterson, N. J.

To facilitate the use of a table of common logarithms we transform the given equation into one in which the desired root is positive. To this end let $x=-y$, $y>0$.

Then $(-y)^{10}=y^{10}=10^{-y}$.

Taking logarithms (base 10), $10 \log y=-y$.

To locate the root, take $f(y)=10 \log y+y$.

We find $f(0)=-\infty$, $f(1)=1$, so that the root lies between 0 and 1, and nearer to 1 than to 0.

Seeking to narrow the limits we find:

$f(0.9)=10(-1+0.95424)+0.9=-10+9.5424+0.9=+0.4424$
$f(0.8)=10(-1+0.90309)+0.8=-10+9.0309+0.8=-0.1691$.

Hence the root lies between 0.8 and 0.9, and nearer 0.8.

The root is easily found by continuing the above process. Thus:

$$f(0.82)=-10+9.1381+0.82=-0.0419$$
$$f(0.825)=-10+9.1645+0.825=-0.0105$$

$$f(0.826) = -10 + 9.1698 + 0.826 = -0.0042$$
$$f(0.8266) = -10 + 9.1730 + 0.8266 = -0.0004$$
$$f(0.8267) = -10 + 9.1735 + 0.8267 = +0.0002.$$

Hence we take $y=0.8267$.

For the original equation, therefore, the required root is $x=-0.8267$.

Also solved by W. E. Buker, Leetsdale, Pa., I. L. Hebel, Golden, Colo., D. Moody Bailey, Athens, W. Va., H. R. Mutch, Glen Rock, Pa., and O. A. George, Mason City, Iowa.

1271. *Proposed by H. Grossman, New York City.*

The sum of alternate coefficients in the expansion of $(a+b)^n$ is 2^{n-1}; the sum of the 3rd, 6th, 9th, etc. coefficients differs from $\frac{2^n}{3}$ by less than 1.

Solved by David Gordon, Brooklyn, N. Y.

If the coefficients of the expansion $(a+b)^n$ are $nC_0, nC_1, \cdots$. Prove (a) the sum of the 2nd, 4th, 6th $\cdots$ coefficients is equal to 2^{n-1}. Since

$$(a+b)^n = nC_0a^n + nC_1a^{n-1}b + nC_2a^{n-2}b^2 + \cdots$$

and

$$(a-b)^n = nC_0a^n - nC_1a^{n-1}b + nC_2a^{n-2}b^2 + \cdots.$$

Subtracting $(a+b)^n-(a-b)^n = 2nC_1a^{n-1}b+2nC_3a^{n-3}b^3 + \cdots$.

Let $a=1$, $b=1$, then

$2^n - 0 = 2(nC_1 + nC_3 + nC_5 + \cdots)$ or $nC_1 + nC_3 + nC_5 + \cdots = 2^{n-1}$.

(b) Prove: The sum of the 3rd, 6th, 9th, etc. coefficients differs from $\frac{2^n}{3}$ by less than 1.

Let $(a+b)^n = nC_0a^n + nC_1a^{n-1}b + nC_2a^{n-2}b^2 + \cdots$.

Also let $a=1$ and $b=\omega$ where ω, ω^2 and 1 are the cube roots of unity.

$$(1+\omega)^n = nC_0 + nC_1\omega + nC_2\omega^2 + \cdots$$
$$\omega(1+\omega)^n = \omega nC_0 + \omega^2 nC_1 + \omega^3 nC_2 + \cdots.$$

Since $1+\omega+\omega^2=0$ and $1+\omega=-\omega^2$, $\omega(-\omega^2)^n = (-1)^n\omega^{2n+1} = \omega nC_0 + \omega^2 nC_1 + nC_2 + \omega nC_3 + \omega^2 nC_4 + nC_5 + \cdots$.

Equating real parts of both members and since the real parts of ω and ω^2 are each $-\frac{1}{2}$ then we have

$$\text{Real part of } [(-1)^n\omega^{2n+1}] = -\tfrac{1}{2}nC_0 - \tfrac{1}{2}nC_1 + nC_2 - \tfrac{1}{2}nC_3 - \tfrac{1}{2}nC_4 + nC_5 \cdots$$
$$= -\tfrac{1}{2}(nC_0 + nC_1 + nC_2 + \cdots) + 3/2(nC_2 + nC_5 + \cdots).$$

Let $nC_2 + nC_5 + nC_8 + \cdots = S$.

And since $nC_0 + nC_1 + nC_2 + \cdots = 2^n$, then the real part of $(-1)^n\omega^{2n+1} = (-\frac{1}{2})(2^n) + \frac{3}{2}S$ or $S = \frac{2^n}{3} + \frac{2}{3}(-1)^n\omega^{2n+1}$. But the maximum value of $\omega^{2n+1} = 1$.

Hence S differs from $\frac{2^n}{3}$ by some quantity less than 1.

Also solved by Norman Anning, University of Michigan, and the proposer.

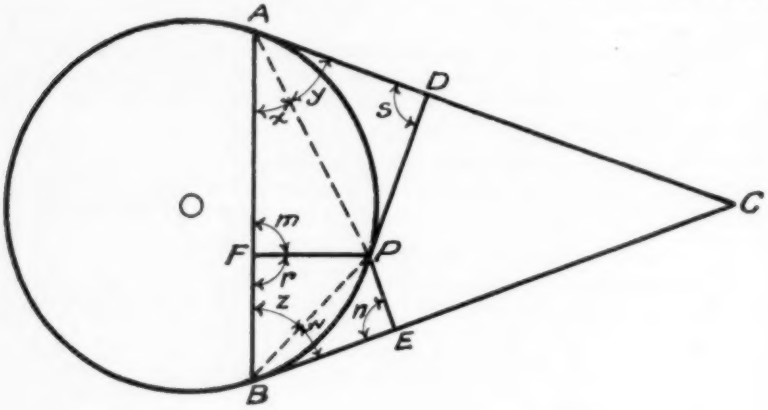
1272. *Proposed by W. E. Batzler, Battle Creek, Mich.*

If two tangents are drawn to a circle from an external point, then the distance from any point on the minor arc to the chord of contact is the mean proportional between the distances to the two tangents from the same point.

Solved by A. Mac Neish, Chicago, Illinois

Given: AC and CB, tangents from point C to the circle with center O. AB the chord of contact. P, any point on arc AB, $PF \perp AB$, $PD \perp AC$, $PE \perp BC$.

Prove: FP is a mean proportional between PD and PE, that is, $\frac{PD}{PF}=\frac{PF}{PE}$.



Draw lines PA and PB

$\angle y$ is measured by $\frac{1}{2}$ arc AP and $\angle z$ is measured by $\frac{1}{2}$ arc AP therefore $\angle y=\angle z$.

$\angle r = \angle s$ being rt. $\angle s$

therefore $\Delta APD\sim\Delta FBP$ and $\frac{PD}{PF}=\frac{AP}{BP}$.

$\angle w$ is measured by $\frac{1}{2}$ arc BP and $\angle x$ is measured by $\frac{1}{2}$ arc BP therefore $\angle w=\angle x$

$\angle m = \angle n$ being rt. $\angle s$

Therefore $\Delta AFP\sim\Delta BEP$ and $\frac{PF}{PE}=\frac{AP}{BP}$

therefore $\frac{PD}{PF}=\frac{PF}{PE}$, things equal to the same thing are equal to each other. Q.E.D.

Also solved by D. Moody Bailey, Athens, W. Va.; Henry Schroeder, Ruston, La.; John E. Bellards, St. Nazianz, Wis.; R. T. McGregor, Elk Grove, Calif.; Richard E. Gadske, Carbondale, Ill.; Dave Gordon, Brooklyn, N. Y.; Angie Lee Rogers, Dexter, N. M.; Bernard Bodeen, Sycamore, Ill.; W. E. Buker, Leetsdale, Pa., F. A. Cadwell, St. Paul, Minn.; Adrian Struyk, Paterson, N. J.; Charles W. Trigg, Los Angeles, Calif.; Mack Tucker, Bremen, Ind.; Theodore A. Love, Brenton, Ala.; and H. R. Mutch, Glen Rock, Pa.

1273. *Proposed by W. E. Buker, Leetsdale, Pa.*

Evaluate $\lim_{x\to\infty} x(a^{1/x}-1)$, $a>0$.

Solved by Leo Aroian, Fort Collins, Colo.

Let $z=\lim_{x\to\infty} x(a^{1/x}-1)$.

Let $x=\frac{1}{y}$ and then by substitution $z=\lim_{y\to 0}\frac{a^y-1}{y}$.

Now z takes the indeterminate form $\frac{0}{0}$.

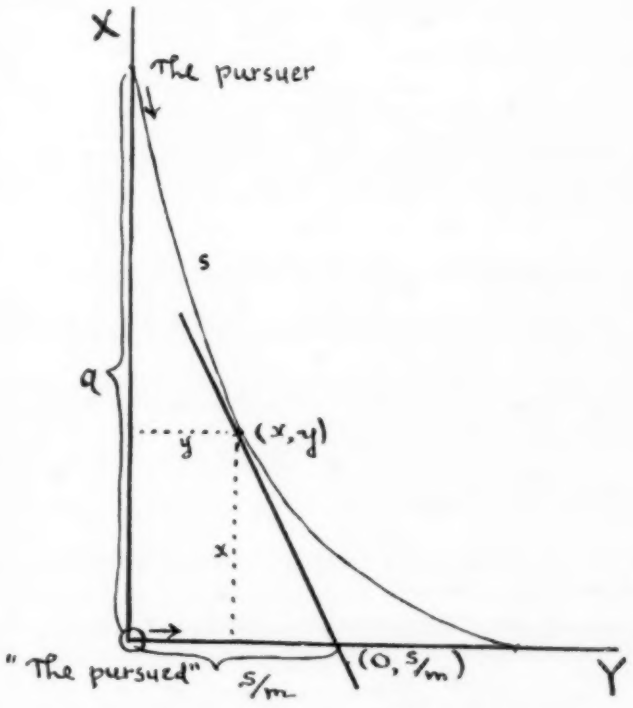
A first differentiation of numerator and denominator gives

$$z = \lim_{y \to \infty} \frac{\log_e a \cdot a^y}{1} = \log_e a.$$

Also solved by Harold G. Shirk, State College, Pa., David Gordan, Brooklyn, N. Y., and Howard R. Harold, Tonkawa, Okla, R. T. McGregor, Elk Grove, California, and O. A. George, Mason City, Iowa.

Note on Problem 1259. The solution presented assumes that the three birds flew in straight lines. As the problem is stated the hawk and eagle must describe curved paths. A solution for the problem as stated will now be offered.

PROBLEM: An eagle, a hawk, and a sparrow are in the air. The eagle is 100 feet above the sparrow and the hawk is 50 feet below it. The sparrow flies straight forward in a horizontal line. The eagle and the hawk start at the same time toward the sparrow. The eagle flies twice as fast as the sparrow. If the eagle and the hawk reach the sparrow simultaneously, how far does each of the three fly?



Solved by Boris Garfinkel, Buffalo, New York

We will first derive the general equation of "the curve of pursuit." Let a = the initial separation of the pursuer and the pursued; m = ratio of their speeds; s and s/m represent their respective distances.

The tangent to the curve at any point (x, y) must pass through the point $(o, s/m)$, the corresponding position of "the pursued."

In $Y-y=\frac{dy}{dx}(X-x)$, the equation of the tangent, substitute $X=O$ $Y=\frac{s}{m}$ obtaining $\frac{s}{m}-y=-x\frac{dy}{dx}$.

Differentiating with respect to x, and replacing $\frac{dy}{dx}$ by p and $\frac{ds}{dx}$ by $-\sqrt{1+p^2}$ we get the differential equation:

$$\frac{1}{m}\sqrt{1+p^2}=x\frac{dp}{dx}.$$

Separating the variables and integrating:

$$\log\left(\sqrt{1+p^2}+p\right)=\frac{1}{m}\log\frac{x}{c_1}$$

$$\therefore \sqrt{1+p^2}+p=\left(\frac{x}{c_1}\right)^{1/m}$$

Solving for p gives

$$(1)\qquad p=\frac{1}{2}\left\{\left(\frac{x}{c_1}\right)^{1/m}-\left(\frac{x}{c_1}\right)^{-1/m}\right\}.$$

Integrating again we find that

$$(2)\qquad y=\frac{mx}{2}\left\{\frac{1}{m+1}\cdot\left(\frac{x}{c_1}\right)^{1/m}-\frac{1}{m-1}\cdot\left(\frac{x}{c_1}\right)^{-1/m}\right\}+c_2$$

Next we determine the constants of integration c_1 and c_2 from the known initial conditions: $x=a$, $y=O$, $p=O$. Substituting these values in (1) and (2) gives

$$(3)\qquad c_1=a \qquad\qquad (4)\qquad c_2=\frac{ma}{m^2-1}.$$

When "the pursued" is overtaken $x=O$. Substituting in (2):

$$(5)\qquad y=c_2=\frac{ma}{m^2-1},$$ the entire distance covered by "the pursued."

We first apply this formula to the case of the eagle by letting $a=100$, $m=2$. Then $y=\frac{2}{3}\times 100=66\frac{2}{3}$ ft.—the distance covered by the sparrow. $my=2\times 66\frac{2}{3}=133\frac{1}{3}$ ft.—the distance covered by the eagle.

In the case of the hawk we let $a=50$, $y=66\frac{2}{3}$.

Then $66\frac{2}{3}=\frac{50m}{m^2-1}$ or $4=\frac{3m}{m^2-1}$.

Solving for m we find that $m=\frac{3+\sqrt{73}}{8}=1.443$ and $my=1.443\times 66\frac{2}{3}=96.2$ *ft.*—the distance covered by the hawk.

Also solved by use of differential equation by Delbert Eggenberger, Illinois Normal University, Normal, Illinois, and W. E. Buker, Leetsdale, Pa.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

1269. Ralph Wilkinson, Sycamore (Illinois) Community High School, Hausen Smith, Battle Creek (Iowa) High School, Lewis and Clark High School Mathematics Club, Spokane, Washington, Wells Coleman, Taft School, Watertown, Conn., Herbert Levy, Fort Wayne, Indiana.

1270. Herbert Levy, Fort Wayne, Ind.

1272. Joanne Wypiszynska, Stevens Point, Wis., Hansen Smith, Battle Creek, Iowa, Herbert Levy, Fort Wayne, Ind., John Ballantine and H. P. Becton, Watertown, Conn.

PROBLEMS FOR SOLUTION

1286. Proposed by Norman Anning, University of Michigan.

The number N consists of p digits each of which is 6. Discover the nature of the product $N(N+1)$. Give a proof that is valid when p is any positive integer.

1287. Proposed by Charles W. Trigg, Cumnock College, Los Angeles.

If the three sides and the area of a triangle are integers, at least one of the altitudes is an integer.

1288. Proposed by C. C. Hunt, Cedar Rapids, Iowa.

In the following equation find the value of x and supply the missing digit represented by the dot.

$$[11(492+x)]^2 = 37 \cdot 10201.$$

1289. Proposed by G. C. Lentini, Boston, Mass.

The volume of a right circular cylinder increases at the rate of m cubic centimeters per second. If at each instant the volume is a maximum for the instantaneous total surface, find the rate of increase of the surface area.

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1290. Proposed by O. L. Darner, Scott City, Kansas.

A captain on horseback stood at the head of a one mile column of soldiers. As the soldiers started forward the captain started toward the rear of the column. Upon arriving at the rear of the column he immediately turned and started toward the head of the column and when he arrived at the head of the column the soldiers had marched exactly one mile. If it took the soldiers 17.2683 minutes to march the mile, how far did the captain travel, if both rates are constant?

1291. Proposed by W. E. Buker, Leetsdale, Pa.

Prove or disprove: If two of the face angles of a trihedral angle are supplementary, the bisector of the remaining face angle is perpendicular to their common side.

BOOK REVIEWS

Directed Studies For the Physics Laboratory, by Burton L. Cushing, Head of the Department of Science, East Boston High School, First Edition. Paper. Pages vi+168, 18.5 x 26 cm. 1932. Ginn and Company.

Directed Studies for the Physics Laboratory is a loose leaf manual to accompany Stewart, Cushing and Towne's *Physics For Secondary Schools*. The material is divided into twenty-four topics under which are included sixty experiments. Each topic is introduced by a statement explaining the purpose of the experiments in that topic. The principle is never stated but suggested in the questions concluding each experinent and each topic. The questions in the conclusions aim at a more generalized statement of the principles.

Each experiment is arranged in the conventional manner; a statement of the object, list of apparatus and a diagram followed by a short concise discussion of the procedure with questions to direct the experiment in his reasoning. The data table is so arranged that the results can be readily analyzed.

Of the sixty experiments fifteen are starred, which may be omitted in shorter courses. In general the selection of the starred sections is appropriate. However, such topics and experiments which treat on density and specific gravity should not be omitted from any introductory course regardless of length.

Tables of physical constants are conspicuously lacking from this manual.

C. RADIUS

Workbook in Physics, by Samuel Ralph Powers, Professor of Natural Science, Teachers College, Columbia University, New York City, and H. Emmett Brown, Teacher of Science, Lincoln School of Teachers College and Instructor in Natural Science, Teachers College, Columbia University. New York City. Paper. Pages ix+294. 20 x 26.5 cm. 1932. Allyn and Bacon, 50 Beacon Street, Boston Massachusetts.

Workbook In Physics by Powers and Brown supplements the textbook, classroom discussion, and laboratory study. It is built around the idea that the student learns best the material to which he actually makes responses, and that unanswered questions stimulate thought processes.

The *Workbook In Physics* contains 100 exercises. None of the major topics of high school physics have been omitted. The material follows the order presented in Fuller, Brownlee, and Baker, *First Principles In Physics*. However, an elaborate table of references to the texts by Black and Davis; Dull; Lynde; and Millikan, Gale and Pyle has been included.

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The statements in the individual exercises proceed from the simple to the more complex. Individual ideas are first formed and then associated into larger concepts. The authors have no fear in the use of elementary mathematics. Wherever advantageous they have developed and used formulas. Some of the topics such as heat and sound have been developed around the energy concept.

Each exercise is quite exhaustive and the total work is far above the minimum requirements for high school physics.

C. RADIUS

Texts and Tests in Plane Geometry, A Combined Textbook, Students' Workbook, and Testbook made for modern Courses, by David Eugene Smith, Teachers College, Columbia University; William David Reeve, Teachers College, Columbia University; Edward L. Morss, Editor of Mathematical Textbooks. Paper. 286 pages 19 x 26 cm. 1933. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price 88 cents.

This book consists of the materials of plane geometry supplemented by test material. It is a geometry text written in work-book size. In some instances the subject matter is arranged in work-book form and space is allowed for the work of pupils. In many instances no space is allowed of pupils' work or for proving theorems. Hence one wonders why this particular form of text was chosen if it was not intended solely for work-book purposes. Certainly the book cannot hold up in classes where one set of books must last for several years. The subject matter is divided into units although some of them are questionable. At the close of each unit there is a page of review or test material and at the close of the book there are twenty-seven tests on the eleven units and five on a general review. The test pages are perforated and can be removed by teachers for use as examinations.

The book is provided with a great number of illustrations which are very attractive and appropriate. The unit page organization is used in that each page is an attack on one particular point noted in its heading.

While some teachers may condemn the book and others praise it highly, its success will be determined when it meets the test of classroom use.

C. A. STONE

Objective Exercises in Units of Plane Geometry, by William W. Strader and Lawrence D. Rhoads of the William L. Dickinson High School, Jersey City, N. J. Paper. Pages iv+82. 20 x 27 cm. 1932. John C. Winston Company, 1006–1016 Arch Street, Philadelphia, Pa. Price 48 cents.

This book consists of a series of exercises covering the field of plane geometry. Apparently each exercise is to be used in supplementing the teaching of corresponding material in a course in plane geometry. As such the purpose of the book is a worthy one. The exercises are somewhat different than the exercises found in most workbooks in that they are presented in the form of tests. Especially is this true of the diagnostic and achievement exercises. The workbook contains two types of exercises: (1) basal learning and practice exercises and (2) general diagnostic exercises. In a separate package accompanying the workbook are found some comprehensive achievement exercises which the authors claim should not come into the hands of the pupils until they are assigned. They are to be used for (1) learning exercises in chapter reviews, (2) diagnostic exercises in chapter reviews, (3) preliminary tests which precede those conducted by the teacher and (4) chapter tests.

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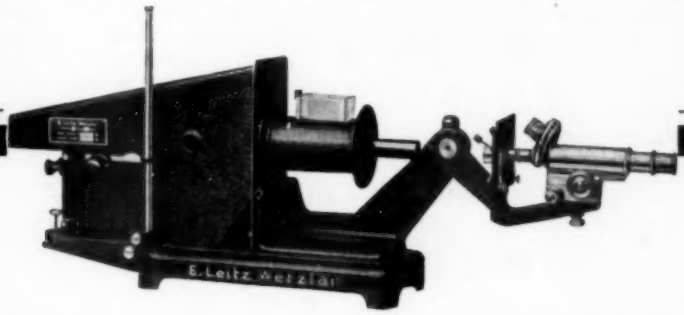

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The authors divide the materials of plane geometry into 33 units for which they are to be criticized since many of the divisions do not possess the characteristics that determine units. It is to be deplored that there is a widespread practice of calling any portion of subject matter a unit for the sake of using progressive terminology. However, the book should prove useful to those teachers of geometry who need additional materials.

C. A. STONE

The Teaching of High School Chemistry, by J. O. Frank, Professor of Science Education and Head of the Chemistry Dept. State Teachers College, Oshkosh, Wisconsin. Fifth Edition; rewritten in 1932. Cloth. Pages vi+285. 21.8×13.7 cm. J. O. Frank and Sons, Oshkosh, Wis.

"It is the purpose of this book to present material which will be of immediate aid to those who are teaching first year chemistry and to offer an interpretation of such evidence as is available regarding many of the unsettled questions regarding instruction in Chemistry." There are nineteen chapters which together with the appendix contain a wealth of information; they are full of valuable suggestions and references, not only for prospective chemistry teachers, but also for those who have had years of experience. Some of the chapters which should be of value to any chemistry teacher are:

> Criticisms of High School Chemistry; Laboratory Teaching; Means and Materials for Enriching the Teaching of High School Chemistry; The Laboratory; and The Teaching of Qualitative Analysis. The Appendix contains a list of 295 projects.

There is hardly a detail in the daily work of a chemistry teacher which has not been adequately touched; many practical hints are given; on debatable topics, various views are presented, and conclusions are drawn accordingly. To the trained and experienced teacher it will seem that some of the material could have been omitted. However, it is stated that "most high school chemistry teachers have had little professional training" and are "comparatively inexperienced." For such this book will clear up a multitude of problematical situations.

At the end of each chapter may be found exhaustive lists of references to books, bulletins, and magazines. SCHOOL SCIENCE AND MATHEMATICS is listed eighty-three times as a reference. It is evident that this book reflects extensive research and experience in the field of chemistry teaching.

The mechanical make-up and printing could be improved.

All prospective as well as active teachers of chemistry should be familiar with this book. It is well adapted as a text for teacher training courses. Librarians will do well to consider it for their professional shelf.

N. F. ROECKER

CAMPHOR FROM TURPENTINE

A new process for making camphor out of turpentine, which may some day render America independent of Japan for its camphor supply, was described by Prof. John J. Ritter of New York University. The possibility of a cheapened source of pure camphor made synthetically is of far greater importance than a mere minor use in medicine, for camphor is used by the ton in the production of smokeless powder and in many industrial processes.

EACH BONE HAS OWN SOUND WHEN TAPPED, RUSSIAN FINDS

Every bone has its own distinct sound when it is tapped, Dr. T. J. Ariev of Leningrad has found. He has proved this by oscillograms taken of several important large parts of the human skeleton. The oscillograms are written records of the sound waves set in motion by the bone when tapped. These written records make possible a much more accurate comparison of the varying sounds of tapped bones than could be obtained merely by listening to them.

The sound of the bones is naturally affected by age, sex, race and individual peculiarities of body build. Whenever there is an inflammation of the bone or it is cracked or broken, the sound undergoes a marked change. This may be readily brought out by comparing the tones of healthy and suspected bones, as practically every bone of the human body has its counterpart, it is claimed.

Dr. Ariev's observation was pronounced a valuable medical advance by a special committee of health authorities and physicists which was set up to examine his method and results. According to Prof. A. F. Joffe of the Russian Academy of Science, who was on this examination committee, it is quite feasible to construct a simple acoustical apparatus for investigation of bones which would produce records of sounds, just as an X-ray machine makes X-ray pictures.—*Science Service.*

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BOOKS RECEIVED

A Laboratory Manual for General College Zoology, by John Peter Wessel, Department of Zoology, Crane College, The Municipal College of the City of Chicago. Cloth. Pages lv+142. 15 x 23 cm. 1933. Harper and Brothers, 49 East 33rd Street, New York, N. Y. Price $1.75.

The Radio Amateur's Handbook, A Complete, Authentic and Informative Work on Radio Telegraphy and Telephony, by A. Frederick Collins. Seventh Edition. Revised by George C. Baxter Rowe. Introduction by Donald McNicol, Editor of Radio Engineering. Cloth. Pages xxviii+419. 16 Illustrations and 110 Figures. 13.5 x 19.5 Cm. 1933. Thomas Y. Crowell Company, 393 Fourth Avenue, New York, N. Y. Price $2.00.

Wild Wings, by Julie Closson Kenly. Cloth. Pages xiv+275. 13 x 20.5 cm. 1933. D. Appleton and Company, 35 West 32nd Street, New York, N. Y. Price $2.50.

Heat and Its Workings, by Morton Mott-Smith, Author of This Mechanical World. Illustrated. Cloth. Pages x+239. 12.5 x 19 cm. 1933. D. Appleton and Company, 35 West 32nd Street, New York, N. Y. Price $2.00.

Modern Solid Geometry, by John R. Clark, The Lincoln School, Teachers College, Columbia University and Arthur S. Otis, Author of Statistical Method in Educational measurement, and Otis Self-Administering Tests of Mental Ability. Revised and Enlarged Edition. Cloth. Pages xx+171 12.5 x 19 cm. 1932. World Book Company. Yonkers-on-Hudson, New York. Price $1.20.

The Geometry of Repeating Design and Geometry of Design for High Schools, by A. Day Bradley, Ph.D., Teachers College, Columbia University, New York City. Cloth. Pages vi+131. 15 x 23 cm. 1933. Bureau of Publications, Teachers College, Columbia University, New York City. Price $1.50.

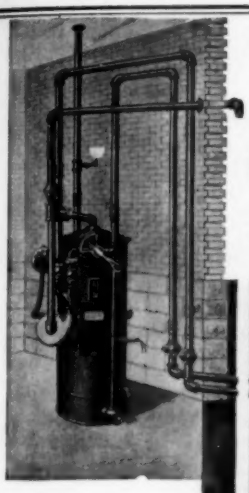
Experimental Optics, by A. Frederick Collins, F.R.A.S. Illustrated. Cloth. Pages xiv+318. 12.5 x 18.5 cm. 1933. D. Appleton and Company, 35 West 32nd Street. New York, N. Y. Price $2.00.

Life's Place in the Cosmos, by Hiram Percy Maxim. Cloth. Pages xi+176. 14 x 21 cm. 1933. D. Appleton and Company, 35 West 32nd Street, New York, N. Y. Price $2.50.

Plane Geometry, by Ray Dwinnell Farnsworth, Head of the Department of Mathematics, Chauncy Hall School, Boston, Mass. with the Editorial cooperation of Ralph Dennison Beetle, Professor of Mathematics, Dartmouth College. First Edition. Cloth. Pages x+258. 13.5 x 20.5 cm. 1933. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y.

Plane Trigonometry, by Cecil A. Ewing, Head of the Mathematics Department in The Tome School with the Editorial Cooperation of Ralph Dennison Beetle, Professor of Mathematics, Dartmouth College. First Edition. Cloth. Pages xi+165. 13.5 x 20.5 cm. 1933. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $1.20.

The McGraw-Hill Five-Place Logarithmic and Trigonometric Tables, prepared under the Editorial Supervision of Ralph Dennison Beetle, Pro-



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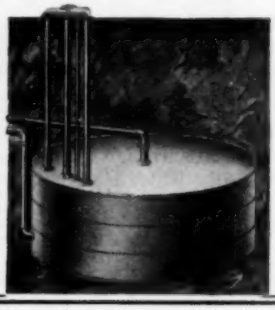

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fessor of Mathematics, Dartmouth College. First Edition. Cloth. Pages vii+131. 13.5 x 20.5 cm. 1933. Price 80 cents. A Combined Edition of Ewing's Plane Trigonometry and McGraw-Hill Five Place Tables is available at $1.60. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y.

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GOALS OF FUTURE RESEARCH ON FOOD AND DIGESTION SET

New goals for scientists to reach in their studies of food and its digestion were set by Prof. Lafayette Mendel of Yale University at the closing session of the Federation of American Societies for Experimental Biology.

Ten major problems in nutrition are awaiting solution, it appeared from Prof. Mendel's remarks. These are:

1. The fate of the fats in the body. This foodstuff commonly constitutes one-third of our daily food fuel intake, but no satisfactory or adequate balance sheet has ever been made to account for it all. Some is used for fuel, some is stored, some is excreted, but there is a missing fraction not yet accounted for, Prof. Mendel pointed out.
2. The fate of the nitrogen-containing foods. The state of knowledge concerning these important foods, more familiarly known as proteins, is nearly as unsatisfactory as in the case of the fats.
3. An appraisal is needed of the relation of the minerals in the diet to such factors as vitamins and internal secretions.
4. The possible value of a number of pigmentary substances, such as chlorophyll, the green coloring matter of plants, needs to be investigated, now that another such substance, carotene, has been found important in connection with vitamin A.
5. Glandular foods, like liver, kidney and thymus, have a new significance in the diet since the discovery of their value in pernicious anemia, and they should be investigated further.
6. Further study of vitamins is required to complete our knowledge of these important factors.
7. The problem of alcohol as a food will probably be revived for further study.
8. Dropsy as a result of faulty diet presents a relatively new problem for investigation.
9. The role played by the organic acids of vegetables, such as citric, malic, tartaric and oxalic acids, which must be taken in considerable quantities in the ordinary diet, needs to be discovered. Vegetables themselves are claimed to have unique advantages in the diet.

"Our knowledge of what actually happens to them chemically in the long reaches of the alimentary tract is woefully limited," Prof. Mendel commented.

10. The way in which products of digestion are transported to other parts of the body deserves further scientific consideration.

In the future, scientific students of nutrition will solve problems such as these, which relate not so much to the composition of the foods we eat or to their effect on the body as to their actual fate in the chemical factories of the digestive tract.—*Science Service.*